

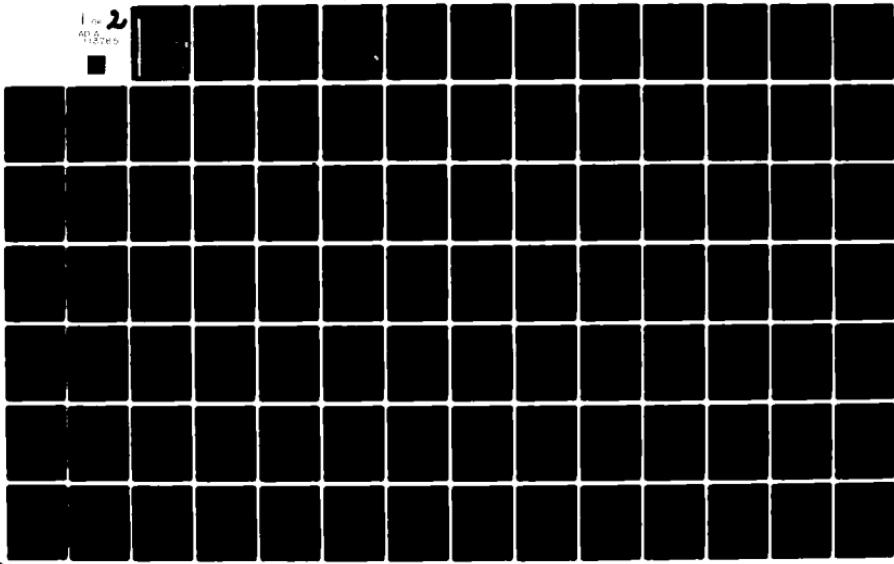
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RANGE COMMANDERS COUNCIL WHITE SANDS MISSILE RANGE NM--ETC F/S 13/12  
UNGUIDED ROCKET SAFETY: AN INFORMAL COMPENDIUM OF RANGE TECHNIC--ETC(U)  
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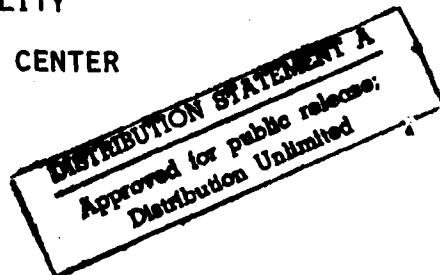
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TECHNICAL REPORT

UNGUIDED ROCKET SAFETY:

AN INFORMAL COMPENDIUM OF  
RANGE TECHNIQUES FOR ASSURING  
SAFETY IN ROCKET TESTING

RANGE SAFETY GROUP  
RANGE COMMANDERS COUNCIL  
  
WHITE SANDS MISSILE RANGE  
KWAJALEIN MISSILE RANGE  
YUMA PROVING GROUND  
  
PACIFIC MISSILE TEST CENTER  
NAVAL WEAPONS CENTER  
ATLANTIC FLEET WEAPONS TRAINING FACILITY  
NAVAL AIR TEST CENTER  
  
EASTERN SPACE AND MISSILE CENTER  
ARMAMENT DIVISION  
WESTERN SPACE AND MISSILE CENTER  
AIR FORCE SATELLITE CONTROL FACILITY  
AIR FORCE FLIGHT TEST CENTER  
AIR FORCE TACTICAL FIGHTER WEAPONS CENTER

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  None.		

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RANGE SAFETY GROUP  
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## TABLE OF CONTENTS

	<u>PAGE</u>
1. Objective . . . . .	1
2. Need. . . . .	1
3. Basic Rocket Safety . . . . .	1
4. Planning Phase. . . . .	2
5. Prelaunch Phase . . . . .	3
6. Post Impact Phase . . . . .	4
7. Individual Range Techniques . . . . .	4

### APPENDIXES

A. Western Space and Missile Center (WSMC) Rocket Safety . . . . .	A-1
B. Eastern Space and Missile Center (ESMC) Rocket Safety . . . . .	B-1
C. White Sands Missile Range (WSMR) Rocket Safety. . . . .	C-1
D. Kwajalein Missile Range (KMR) Rocket Safety . . . . .	D-1
E. Air Division (AD) Rocket Safety . . . . .	E-1
F. Naval Weapons Center (NWC) Rocket Safety. . . . .	F-1
G. NASA Wallops Flight Center (NASA/WFC) Rocket Safety . . . . .	G-1

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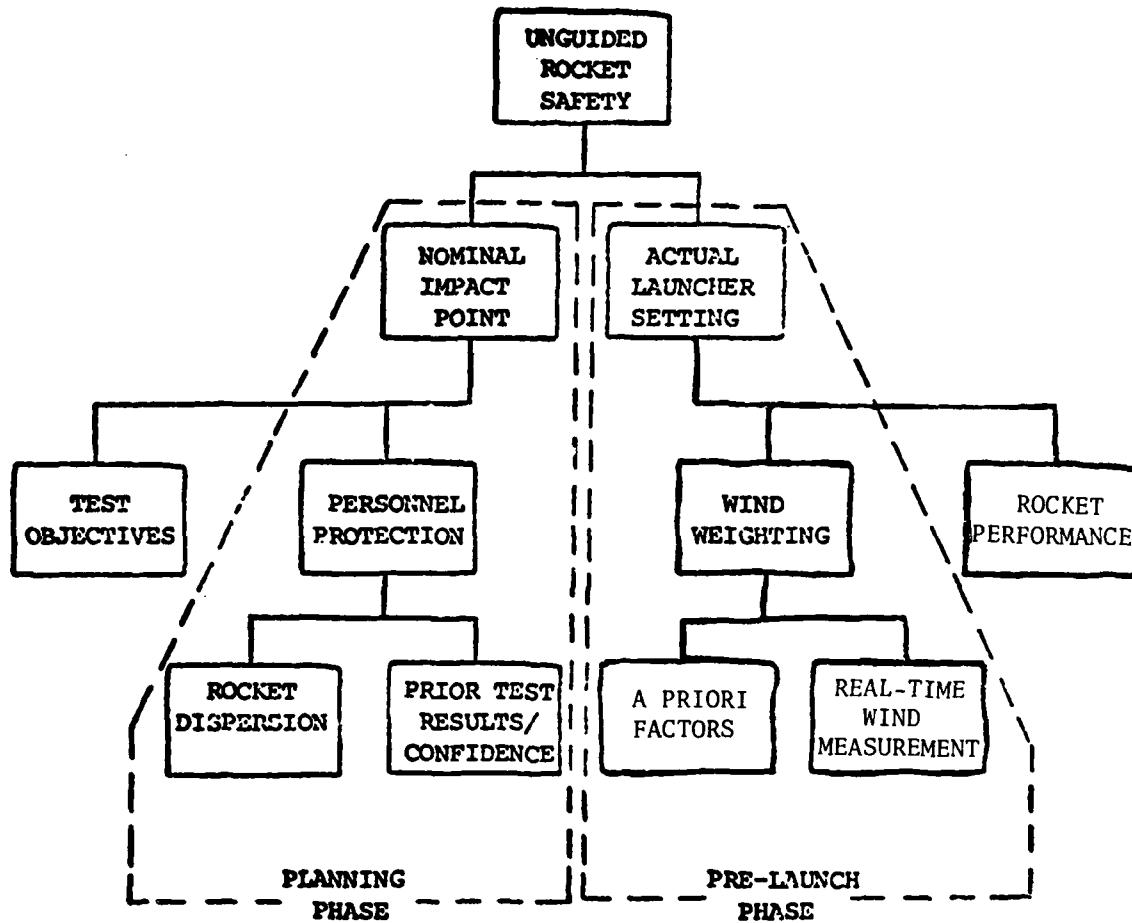
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## UNGUIDED ROCKET SAFETY

1. OBJECTIVE: This document contains summaries and extracts of techniques employed by various Range Commanders Council (RCC) member ranges and associate member agencies in analyzing unguided rocket programs to obtain a safety solution to rocket launches. Unique techniques that may be beneficial to other ranges will be described in detail. Any recommendations supporting the use of various techniques will also be included. The intent of this informal report is to provide, in a single document, a compendium of rocket testing approaches for ranges and potential rocket programs for reference, planning and evolving new support techniques. ↵
2. NEED: The safety solution to unguided rocket launches depends upon many factors. Included among these are measuring launch day winds and properly setting the launcher to compensate for the wind effects, accurately determining contributions to trajectory dispersion and evaluating the effects on the impact location, and evaluating performance data from prior launches of the same or similar rockets. As National Ranges begin to launch new, larger and more sophisticated unguided rockets, the need exists to reevaluate the methods employed in obtaining a satisfactory safety solution. This document will be useful in determining areas of improvement in rocket safety or in defining system upgrades that enhance the range safety control of unguided rockets.
3. BASIC ROCKET SAFETY: Range safety control of unguided rockets, unlike that of guided rockets or missiles, terminates at lift-off. Since there are no real-time inflight safety controls, safety has to be engineered into the program planning and prelaunch phases. Neither phase can stand alone; both

are required to make a rocket launch successful from the safety and operations standpoints. The hierarchy of unguided rocket safety can be expressed by the following diagram:



4. PLANNING PHASE: The selection of a nominal impact point requires the factoring of user test objectives with the requirement for providing protection to nonessential personnel. Where a limited test area exists, there is often a

need to conduct a trade-off study of risk to people versus risk to the program. Maximizing personnel protection by requiring an arbitrary, large, standoff of the nominal impact point from population centers can compromise a mission's success to the point where a test may not be conducted. Therefore, it is necessary to have an accurate prediction of a rocket's inflight behavior so that personnel protection decisions can be the basis of probability studies. The prime inputs into the prediction process are theoretical rocket dispersion data and empirical data from past firing programs. Armed with accurate impact dispersion information, range safety personnel can establish standoff boundaries that keep risks to personnel at an acceptable level. A user can then plan his test program around these safety requirements.

5. PRELAUNCH PHASE: With the establishment of a safe nominal impact point, the final range safety responsibilities are accomplished by controlling the actual azimuth and elevation settings of the launcher. These settings depend on the rocket's performance capability and the effect that real-time wind has on the flight of the rocket and the resultant impact. Normally, the launcher is positioned to maintain the nominal impact point. For a multi-stage rocket, this means that the payload is targeted to a predetermined location and the lower stage motors are left to impact at will. Frequently, these impacting stages are also a safety problem. When this is the case, prelaunch predictions of their impact locations are required and launcher settings are determined that will place these impacts in a safe location; hopefully, without severe compromise of the payload impact requirements. In all cases, range safety is concerned with the predefined effects that wind has on a rocket's trajectory

and the associated a priori factors of these effects, the accurate measurement of prelaunch winds, and the ability to compute launcher settings.

6. POST IMPACT PHASE: A highly useful procedure utilized as range geographical sensitivity dictates is that of a post flight comparison of actual to anticipated trajectory. Analysis of cause for suspected irregular missile flight performance (as determined through comparison of last radar position to nominal positioning) serves to validate both missile dispersion data and meteorological procedures. Even a cursory check on impact will act to reveal trends and thereby significantly reduce test risk associated with multiple unchecked launches. While this is not discussed in the appendices to follow, it is nonetheless often a part of an effective unguided rocket safety program and utilized in varying degrees by all ranges.

7. INDIVIDUAL RANGE TECHNIQUES: The appendixes in this document provide an overview of techniques employed by the various ranges to ensure unguided rocket safety. Methods may be categorized into several basic areas:

- a. Initial Rocket Dynamics Data
- b. Launcher Determining Methods
- c. Hazard Area Determination
- d. Monitoring Real Time Weather Effects
- e. Test Review of Irregularities

These methods, while somewhat different in approach, reflect a tried and proven technique for safety control of flight test vehicles developed within the framework of geography, test objectives and range test interests.

Appendix A

WESTERN SPACE AND MISSILE CENTER (WSMC)  
ROCKET SAFETY

(IPSRM PROGRAM)

WESTERN SPACE AND MISSILE CENTER (WSMC)  
ROCKET SAFETY

UNGUIDED ROCKET SUPPORT

1. WSMC Flight Safety Analysis (SEY) provides ballistician support for unguided short-range rocket launches. This support consists of compiling wind data, and processing the wind and rocket characteristic data through the IBM 360/65 computer by use of the IPSRM program. The results of the IPSRM program are the launcher settings, in terms of azimuth and tilt angle, and the impact locations of stages in range and bearing from the launch point. The output data are reviewed by the ballistician to ensure that all safety constraints are met.
2. The wind data consists of rawinsonde data, radar balloon tracking data, and wind tower data. The rawinsonde data provides the upper altitude data from 5,000 to 50,000 feet. The radar balloon track data provide the middle altitude data from 500 to 5,000 feet. The wind tower data provides the lower altitude data below 500 feet. The IPSRM program selects wind data from the above three data sources, giving priority to the wind tower data, then the radar balloon track data, and finally the rawinsonde data. The radar balloon track data and the wind tower data are updated at 20- to 30-minute intervals in order to provide launcher setting trend data.

- 3 Atch
1. Data Flow
  2. Launcher Settings
  3. Program Listing

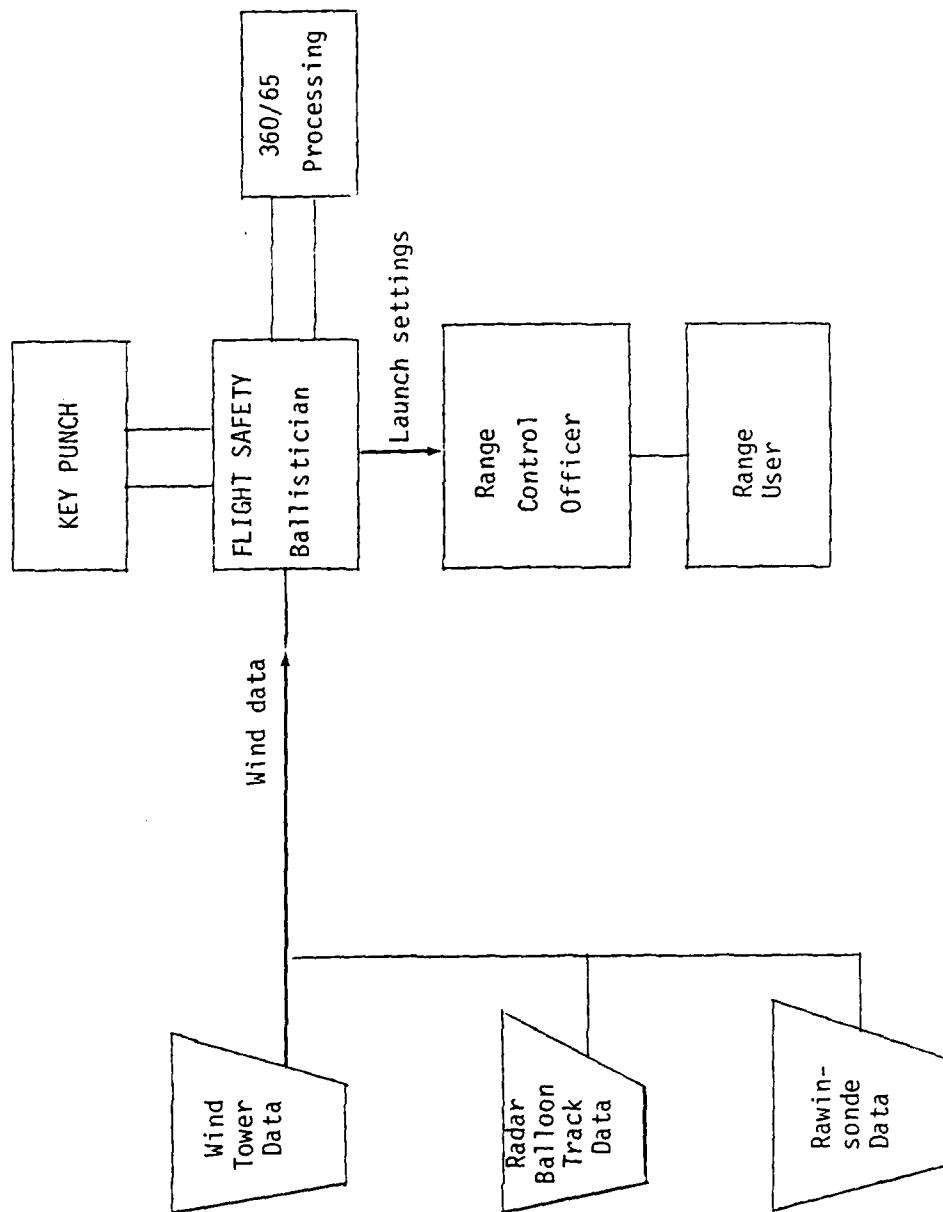


Figure 1. Data Flow

Atch 1

## LAUNCHER SETTINGS

### 1. DESCRIPTION

- a. General: IPSRM provides launcher tilt angle and launch azimuth for short-range unguided missiles taking into consideration the effects of local wind conditions. Predicted impact points for all booster stages (maximum of five) are also provided by this data item.
  - b. Specific Output: The specific IPSRM output is controlled by user option. See Attachment 2a for output formats.
  - c. When Produced: The IPSRM output is produced pre-operation.
  - d. Where Produced: The IPSRM output is produced using the IBM 360/65 computers.
  - e. How Produced: The IPSRM output is produced using the WSMC certified software program IPSRM. The program is used in the operational support mode and the WSMC flight safety ballistician must attend the run on the IBM 360/65. The input data comes direct to the keypunch station and is punched in the required format and delivered to the flight safety ballistician who must verify the correctness of the keypunch and then deliver the data to the 360/65 computer operator. The data is then loaded through the online card reader and the results are printed online.
  - f. When Available: The IPSRM is available to the flight safety ballistician as soon as printing is completed.
2. PRECONDITIONS. The flight safety ballistician must attend the run on the IBM 360/65 computer. All inputs must be verified by the representative prior to running.
  3. PHYSICAL DESCRIPTION. The IPSRM output is a tabular print on fan-fold paper. The above table data will be printed for each missile stage with the order of the print from upper stage to lower stage.

A-4

### SPECIFIC IPSRM OUTPUT CONTENT

1. The user supplied contents of the header card are printed online.
2. The input data will be printed online in the following format:

NUMBER OF STAGES	ONLINE PRINT	RADAR INPUT	NUMBER OF TABLE ENTRIES PER STAGE				
			ONE	TWO	THREE	FOUR	FIVE
X	X	X	XX XX	XX XX	XX XX	XX XX	XX XX

The above outputs are all integer values.

RADAR ALTITUDE	PAD ALTITUDE	LAUNCH TILT	LAUNCH AZIMUTH	IMPACT RANGE	IMPACT AZIMUTH	ALLOWABLE TOLERANCE
XXX.X	XXX.X	XX.X	XXX.X	XXX.X	XXX.X	X.X

Where:

Radar Altitude in feet  
 Pad Altitude in feet  
 Launch Tilt in degrees  
 Launch Azimuth in degrees  
 Impact Range in nautical miles  
 Impact Azimuth in degrees  
 Allowable Tolerance in nautical miles

#### STAGE X (Integer number)

ALTITUDE	WIND WEIGHT	LAUNCH TILT	BALLISTIC FACTOR		
			IMPACT RANGE	IN-RANGE	CROSS-RANGE
XXXXXX.	X.XXXX	XX.X	XXX.XXXX	X.XXXX	X.XXXX

Where:

Altitude in feet  
 Wind Weight - N/A  
 Launch Tilt in degrees  
 Impact Range in nautical miles  
 Ballistic Factor In-Range in nautical mile/feet/second  
 Ballistic Factor Cross-Range in nautical mile/feet/second

Atch 2a

3. If the wind print flag is set, the wind input data will be printed online in the following format:

TOWER SAMPLES	RADAR SAMPLES	RAWINSONDE SAMPLES	WIND PRINT	MULTI CASE	ONLINE PRINT	ITERATION PRINT	ITERATION LIMIT
X	XX	XXX	X	X	X	X	XX

The above outputs are all integer values.

TOWER INPUT

ALTITUDE	DIRECTION	SPEED
XXX.	XXX.	XX.

Where:

Altitude in feet  
Direction in degrees  
Speed in knots

RADAR INPUT

TIME	RANGE	AZIMUTH	ELEVATION
XXX.	XXXX.	XXXX.	XXX.

Where:

Time in seconds  
Range in yards  
Azimuth in mils or degrees  
Elevation in mils or degrees

RAWINSONDE INPUT

ALTITUDE	DIRECTION	SPEED
XXXXXX.	XXX.	XX.

Where:

Altitude in feet  
Direction in degrees  
Speed in knots

4. Reduced wind data will be printed online in the following format, if the option is selected:

ALTITUDE (FT)	DIRECTION (DEG)	SPEED (KN)	X VELOCITY (FT/S)	Y VELOCITY (FT/S)
XXXXXX.X	XXX.X	XX.X	XXX.XX	XXX.XX

5. If iteration is required to compute the launcher settings, the intermediate results are printed online.

ITERATION NUMBER	LAUNCH TILT ANGLE	LAUNCH AZIMUTH	COMPUTED IMPACT RANGE	COMPUTED IMPACT AZIMUTH	DELTA DISTANCE IN-RANGE	DELTA DISTANCE CROSS-RANGE
XX	XX.X	XXX.X	XXX.X	XXX.X	X.XX	X.XX

Where:

Iteration Number is an integer value  
 Launch Tilt in degrees  
 Launch Azimuth in degrees  
 Computer Impact Range in nautical miles  
 Computer Impact Azimuth in degrees  
 Delta Distance In-Range in nautical miles  
 Delta Distance Cross-Range in nautical miles

6. The launch and impact parameters and the ballistic wind components are printed for each missile stage. A wind set number is incremented internally and printed to also identify the data. The quadrant elevation angle is printed for upper stage only. The data are presented in the following format:

WIND SET X STAGE X						
WCI	WCC	TILT	LAUNCH AZIMUTH	IMPACT RANGE	IMPACT AZIMUTH	QE
XX.X	XX.X	XX.X	XXX.X	XXX.X	XXX.X	XX.X

Where:

Wind Set and Stage are integer values  
 WCI - Ballistic wind component in-range in feet per second  
 WCC - Ballistic wind component cross-range in feet per second  
 Tilt - Launch tilt angle in degrees  
 Launch Azimuth in degrees  
 Impact Range in nautical miles  
 Impact Azimuth in degrees  
 QE - Quadrant Elevation - in degrees

## WIND INPUT DATA SHEET

OPERATION NUMBER \_\_\_\_\_ DATE \_\_\_\_\_

RUN NUMBER \_\_\_\_\_

## RADAR WIND DATA

TIME Col. 1-10	RANGE (Yds) (0.-99999.) Col. 11-20	AZIMUTH (Mils) (0.-6400.) Col. 21-30	ELEVATION (Mils) (0.-1699.) Col. 31-40
000.			
020.			
040.			
060.			
080.			
100.			
120.			
140.			
160.			
180.			
240.			
300.			
360.			

## WIND TOWER DATA

ALTITUDE Col. 1-10	DIRECTION (0.-360.) Col. 11-20	SPEED (0.-999.) Col. 21-30
364.		
412.		
514.		

## OPTION CARD

NTOW Col. 4-5	NRAD Col. 9-10	NRAW Col. 13-15	Col. 21-30
3			1

NTOW = NUMBER OF WIND TOWER SAMPLES

NRAD = NUMBER OF RADAR SAMPLES

NRAW = NUMBER OF RAWINSONDE SAMPLES

(Leave blank if previously stored rawinsonde data is to be used)

FORTRAN IV LEVEL 21

-1-

DATA1 = H1215 DATA2 = 06/05/01

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卷之三

JURKAN IV G LEVEL

MAIN

MAIN

PAGE 0002

LATE = 81215

0031        WRITE(6,450) SCALT,PDALT,TCLER  
0032        KSTG = NSTG  
0033        DC 200 K=1,NSTG  
0034        WRITE(6,455) KSTG  
0035        KSTG = KSTG-1  
0036        NT1 = NTE1(K)  
0037        NT2 = NTE2(K)  
0038        IF (NT1 .GT. NT2) GO TO 170  
0039        LL = NT1  
0040        LL = NT2  
0041        GO TO 180  
0042        GO TO NT2  
0043        LL = NT2  
0044        LL = NT1  
0045        CCNTINUE  
0046        WRITE(6,500) (ALIT(K,I),WLT(K,I),TLIT(K,I),FNGT(K,I),BFIRT(K,I)).  
0047        \*        RFCRT(K,I),I=1,LL  
0048        IF (NT2 .EQ. NT1) GC TO 200  
0049        J = LL+1  
0050        IF (LU .EQ. NT2) GO TO 190  
0051        WRITE(6,510) (ALIT(K,I),WLT(K,I),I=J,LU)  
0052        GC TO 200  
0053        WRITE(6,520) (TLIT(K,I),FNGT(K,I),BFIRT(K,I),RFCRT(K,I),I=J,LU)  
0054        CCNTINUE  
0055        CC 210 NT=1,NSTG  
0056        K = KIE1(NT)  
0057        DC 210 I=1,P  
A-10        C \*\*\* PDALT IS THE HEIGHT OF THE LAUNCH SITE ABOVE MSL AN SEA LEVEL  
0058        0059        ALT(NT,I) = ALIT(NT,I)+PDALT  
0060        CCNTINUE  
0061        C \*\*\* LATHR IS A SUBROUTINE THAT READS IN THE WIND DATA  
0062        210 CCNTINUE  
0063        C \*\*\* WDR IS A SUBROUTINE THAT REDUCES THE WIND DATA  
0064        0065        CALL LNDR  
0066        C \*\*\* FCNTR IS A SUBROUTINE THAT COMPUTES LAUNCHER SETTINGS OR IMPACT\*\*\*  
0067        1000 CCNTINUE  
0068        C \*\*\* NRUN IS A FLAG INDICATING MULTIPLE CASE RUN OR SINGLE RUN  
0069        C \*\*\* 1 - INDICATES MULTICASE RUN  
0070        C \*\*\* FLANK - INDICATES SINGLE CASE RUN  
0071        C \*\*\* 220 IF (NRUN .EQ. 0) CALL EXIT  
0072        REACCS(400) HCR(I,I).I=1,12  
0073        WRITE(6,530)  
0074        FCNTR(IH1)  
0075        530 FCNTR(IH1) FOR  
0076        GC TO 215  
0077        400 FCNTR(124)  
0078        410 FCNTR(15X,12A4)  
0079        420 FCNTR(125)  
0079        440 FCNTR(7F16,C)  
0079        440 FORMAT(4X,6NLMEFR,9X,SHRADAF,16X,13HNUMBER OF TABLE ENTRIES PLH S

PAGE 0002

MAIN

LATE = 81215

PAGE 0002

MAIN

PAGE 0002

F001HAD IV 0. LIVII 21  
 MAIN  
 DATE = 111215, 06/56/01  
 PAGE 0003  
 \* STAGE 4X, OUTPUT STAGE S, 6X, SHINPUT, 13X, SHCNE, 7X, SHTWO, 6X, SHTHREE, 5X.  
 \* AFFLUX, 6X, 4\*FIVE  
 0080 470 FCINAT (150, 17, 15, 12X, 5(12, 14, 4X))  
 0081 480 FCINAT (4X, SHPAR, 10X, 3FPAD, 12X, 9HALLOWABLE/4X, SHALTITUDE, 7X,  
 14HALTITUDE, 7X, SHTOLERANCE)  
 490 FCINAT (1IC, 1, F15, 1, F15, 1, /, /)  
 0082 495 FCINAT (1F1, 14X, SHSTAGE, \*11)  
 0083 500 FCINAT (F14, 0, F16, 4, F15, 1, F16, 4, F15, 4, F14, 4)  
 0084 505 FCINAT (72X, 1, SHREALISTIC, FACTCH/8X, SHALTITUDE, 0X, SHWIND WEIGHT,  
 0085 510 \* 4X, 1SHLAUNCH TILT, 4X, 12HIMPACT RANGE, 5X, SHN-RANGE,  
 \* 4X, 1SHCROSS-RANGE)  
 515 FCINAT (F14, 0, F16, 4)  
 520 FCINAT (30X, F15, 1, F16, 4, F15, 4, F14, 4)  
 END  
 0086  
 0087  
 0088



A-13





WINDK  
DATE = 01215  
06/56/01  
PAGE 0003  
0104 E20 FFORMAT(1H \*7X,1H(F11.1),12X,9H(KNGTS),12X,7H(KNGTS),12X,8H(FYSSC)  
1) ,12X,8H(FYSSC)  
0105 E30 FFORMAT(3X,F10.1,2F20.1,2F20.1)  
0106 E40 FFORMAT(3EX.1E+HJ WIND INPUT DATA)  
0107 END



MAIN IV - LIVII

LNCRA

06/56/01

PAGE 0002

142 C \*\*\* OBTAIN NEW VALUE FOR LNCHTA USING VALUE OF IMPRINT  
143 K1=1 CALL SLI (LADPAC,RNGT,LNCHTA,TILT,NTF2(NS),N3)  
144 IF (KCUT \* NE \* C) RETURN  
145 C \*\*\* OBTAIN VALUE OF DELTAP FROM BALLISTIC FACTOR IN-RANGE TABLE  
146 CALL SLI (LNCHTA,TILT,DELTAP,UFIRT,NTF2(NS),N2)  
147 IF (KCUT \* HE \* C) RETURN  
148 C \*\*\* OBTAIN VALUE OF DELTAS FROM BALLISTIC FACTOR CROSS-RANGE TABLE  
149 CALL SLI (LNCHTA,TILT,DELTAS,BFCRT,NTF2(NS),N2)  
150 IF (KCUT \* NE \* O) RETURN  
151 C \*\*\* CALCULATE IN-RANGE AND CROSS-RANGE CORRECTIONS  
152 CX=DELTAH\*WC1  
153 CY=CFLTAH\*WC1  
154 XH = IMPRINTX/2.  
155 YH = CY  
156 C \*\*\* OBTAIN NEW VALUE FOR LNCHTA USING VALUE OF XR  
157 CALL SLI (XF,RNGT,LNCHTA,TILT,NTF2(NS),N3)  
158 IF (KCUT \* NE \* C) RETURN  
159 C \*\*\* FIND CORRECTED VALUE OF LAUNCH AZIMUTH  
160 ANGATAN (AES(XY),AES(XF))\*CINV2  
161 IF (CY \* GT \* C) GO TO 400  
162 LNCHA2=IMPA2-ANG  
163 GC TU 410  
164 LNCHA2=IMPA2+ANG  
165 410 IF (LNCHA2 \* LT \* 0.) LNCHAZ = 300.+LNCHAZ  
166 IF (LNCHA2 \* GE \* 360.) LNCHAZ = LNCHAZ-360.  
167 C \*\*\* COMPUTE BALLISTIC WIND COMPONENTS DOWN THE LAUNCH AZIMUTH  
168 GC TO 300  
169 C \*\*\* THE IN WIND IMPACT RANGE IS OBTAINED FROM TILT VERSUS RANGE TABLE  
170 CALL SLI (LNCHTA,TILT,RNGT,NTF2(NS),N2)  
171 IF (KCUT \* NE \* O) RETURN  
172 C \*\*\* OBTAIN VALUE OF DELTAH FROM BALLISTIC FACTOR IN-RANGE TABLE  
173 CALL SLI (LNCHTA,TILT,DELTAP,UFIRT,NTF2(NS),N2)  
174 IF (KCUT \* NE \* C) RETURN  
175 CX = DELTAP\*WC1  
176 CY = DELTAS\*WC1  
177 CX = RANGE-EX  
178 CY = CY  
179 C \*\*\* LAUNCH SETTINGS ARE TESTED BY COMPUTING THF ACTUAL IMPACT POINT  
180 C \*\*\* IMPACT RANGE AND AZIMUTH ARE COMPUTED  
181 C1=SGRT((XY\*2+HY\*2)\*  
182 ANGATAN (AES(XY),AES(XR))\*CINV2  
183 IF (CY \* GT \* O) GO TO 550  
184 C1A = LNCHA2+ANG  
185 GC TU 420  
186 C1A = LNCHA2-ANG  
187 CONTINUE  
188 IF (C1A \* CL \* 300.) CIA=CIA-30.  
189 IF (KSCL \* NE \* O) GC\_TC\_C50  
190 IF (C1A \* LT \* C) CIA=60+CIA  
191 GC TO 900  
192 C \*\*\* TEST VALUES AGAINST INPUT VALUES TO DETERMINE IF COMPUTED IMPACT  
193 ACIN IS SUFFICIENTLY CLOSE TO THE DESIRED IMPACT POINT  
194 CIA=IMPA2-CIA

ORTRAN IV, LEVELI 21  
 0091 IF (LNLTA = 0.0) GO TO 1000  
 0092 IF (CIA = 0.0) CIA = 360.0 CIA  
 0093 C \*\*\* CA = INTERGRATION TABS (DELTAA/CCV2)  
 C \* \* IF DA GRATER THAN TOL, PRINT INTERMEDIATE VALUES FOR LNLTA,LNLHAZ  
 0094 -  
 0095 IF (ABS(CA) .LT. INC(LA)) COMPUTE NEW ESTIMATE FOR LNLHAZ  
 0096 IF (LNLTA .LT. 0.0) GC TO 800  
 0097 IF (LNLTA .GT. 0.0) GC TO 670  
 0098 WRITE(6,111)  
 0099 WRITE(6,112)  
 D100 CONTINUE  
 IF (ITRP .EQ. 1) GO TO 675  
 0101 WRITE(6,222) IC,LNLTA,LNLHAZ,CIR,CIA,DR,DA  
 0102 675  
 0103 CCNTINUE  
 IC=IC+1  
 C \*\*\* IF ITERATION COUNT EXCEEDS LIMIT, PRINT ERNCH MESSAGE AND QUIT  
 0104 IF (IC .LT. ILM) GC TO 680  
 0105 WRITE(6,223)  
 RETURN  
 D107 680 LNLHAZ=LNLHZ+DELTAA  
 0108 IF (LNLHAZ .LT. 0.0) LNLHAZ = 360.0 LNLHAZ  
 0109 IF (LNLHAZ .GE. 360.0) LNLHAZ = LNLHAZ-360.  
 C \*\*\* TRANSFER CURRENT COMPUTED ALLISTIC WEND COMPONENTS DOWN LNLHAZ  
 C THIS LGUP IS CONTINUED UNTIL DA IS LESS THAN OR EQUAL TO TOL  
 0110 GC TU 200  
 CR = IMPING-CIR  
 IF (AES(DF) .LT. 0.0) GC TC 810  
 0111 IF (IC .GT. 1) GR TC 810  
 0112 IF (ITRP .EQ. 1) GC TC 810  
 0113 WRITE(6,111)  
 0114 WRITE(6,112)  
 0115 CCNTINUE  
 0116 IF (ITRP .EQ. 1) GO TC 820  
 0117 WRITE(6,223)  
 0118 RETURN  
 0119 800 IC = IC+1  
 0120 IF (IC .LT. ILM) GC TO 850  
 0121 WRITE(6,223)  
 0122 RETURN  
 0123 850 RANGE = RANGE+DF/2.  
 0124 CERTAIN LNCHTA FROM RANGE VERSUS TILT TABLE  
 0125 CALL SLI(RANGE,RNGT,LNLTA,TLLT,NE2(NS),NS)  
 0126 IF (KCUT .NE. 0) RETURN  
 0127 GC TU 500  
 0128 900 IMPAZ = CIA  
 0129 WRITE(6,4020) KCUT,KS  
 0130 IF (NS .NE. 1) GO TC 950  
 0131 C \*\*\* CERTAIN FF(M FNG VERSUS TILT TABLE)  
 0132 CALL SLI(TP,FNG,RNGT,TLLT,NE2(NS),NS)  
 0133 IF (KCUT .NE. 0) RETURN  
 C \*\*\* THE NC WING GLACRANT ELEVATION ANGLE IS COMPUTED IF IT IS THF  
 C - LEPER STAGE  
 0134 CE=90.0-T  
 0135 WRITE(6,533)  
 0136 WRITE(6,3234) UC,F,WCC,LNLTA,LNLHAZ,IMPING,IMPAZ,QF  
 0137 GC TC 1000  
 0138 CCNTINUE  
 0139 WRITE(6,4000)

BATH = H1215

06/56/01

AUT 603

\* SUBROUTINE IV, I-VIL 21  
 LANCH  
 DATE = 81215  
 PAGE 0004  
 00/06/01  
 0140        C \* 4 \* WRITE (6,4010) 'C11\*WCC\*LNC11TA:LNC11AZ\*IMPING\*IMPAT'  
 THE STAGE COUNTER IS INCREMENTED BY 1 AND IF ANY STAGES REMAIN  
 COMPUTATION CONTINUES AT ELLIPTIC WIND COMPONENT CALCULATIONS  
 0141        NS = NS+1  
 0142        KS = KS-1  
 C \*\* WHEN COMPUTATIONS ARE COMPLETED FOR ALL STAGES, CONTROL RETURNS  
 TO THE MAIN ROUTINE  
 0143        IF (NS.GT.NS1) RETURN  
 0144  
 0145        KK = 100  
 KK = 200  
 KK = 300  
 KK = 400  
 KK = 500  
 KK = 600  
 KK = 700  
 KK = 800  
 KK = 900  
 KK = 1000  
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FORTRAN IV 6 LEVEL 21  
 SLI  
 SUBROUTINE SLI((X,YTAU,Y,YTAE,IND,X,N))  
 COMMON/STL/ALT(5,50),W(5,50),TL1(5,50),RNGT(5,50)  
 \* RCT(5,50),TE(5,50),NTE(5,50),NS  
 COMMON/RUN/N  
 COMMON/ERR/ KCLT  
 C \* \* \* THIS SUBROUTINE PERFORMS LINEAR INTERPOLATION  
 C \* \* \* X IS THE INPUT ARGUMENT TO THE SUBROUTINE  
 C \* \* \* XIAF IS THE INDEPENDENT TABLE  
 C \* \* \* Y IS THE DEPENDENT VARIABLE OBTAINED FROM THE SUBROUTINE  
 C \* \* \* YLAB IS THE DEPENDENT TABLE  
 C \* \* \* INDEX IS THE NUMBER OF ENTRIES IN THE INDEPENDENT TABLE XTAB  
 C \* \* \* N INDICATES THE TABLE USED. ALTITUDE, TILT, CR PANG  
 C \* \* \* NS IS THE NUMBER OF THE STAGE  
 C \* \* \* DIMENSION XTAB(5,50),YTAB(5,50),NAME(3)  
 DATA NAME/4HTLT,4HTLT,4HTLT/  
 C \*\*\* CHECK INPUT ARGUMENT AGAINST LIMITS OF TABLE  
 IF ((X .LT. XTAB(NS,1)) .OR. (X .GT. XTAB(NS,INDEX))) GO TO 30  
 DL S IF S .EQ. 2, INDEX  
 IF(X-XTAB(NS,1))12,10,5  
 10 CONTINUE  
 11  
 12 Y=XTAB(NS,1)  
 13 RETURN  
 14 --12-- Y=XTAB(NS,1)+(X-XTAB(NS,1))\*(XTAB(NS,1)-XTAB(NS,1))/  
 \* (XTAB(NS,1)-XTAB(NS,1))  
 15 RETURN  
 16 30 WRITE(6,40) X,NAME(1)  
 WRITE(6,50) (XTAB(NS,II),II=1,INDEX)  
 KCLT = 1  
 RETURN  
 19 40 FORMAT(1H \*EVALUE CF.F10.2,1X,3HIN ,A4,23H TABLE 1S OUT OF BOUNDS  
 1) END  
 21 FORMAT(1HF11.3)  
 END  
 22

NUMBER OF STAGES	RADAR INPUT		NUMBER OF TABLE ENTRIES PER STAGE		
	LNE	TWC	THREE	FOUR	FIVE
2	0	23	4	4	
RADAR ALTITUDE	PAD	ALLOWABLE			
356.0	ALTITUDE	TOLERANCE			
	242.0	0.0			

BALLISTIC FACTOR					
ALTITUDE	WIND WEIGHT	LAUNCH TILT	IMPACT RANGE	IN-RANGE	CROSS-FACTOR
16.	0.0	2.0	52.5300	2.7649	2.7155
25.	0.0620	6.0	94.4300	2.4440	2.6166
35.	0.1620	10.0	145.7800	1.6597	2.4440
45.	0.2550	14.0	181.4200	1.1027	2.2046
50.	0.3270				
60.	0.3900				
70.	0.4540				
80.	0.5150				
90.	0.5640				
100.	0.6220				
110.	0.6840				
120.	0.7220				
130.	0.7550				
140.	0.7850				
150.	0.8110				
160.	0.8380				
170.	0.8630				
180.	0.8880				
190.	0.9120				
200.	0.9380				
210.	0.9620				
220.	0.9850				
230.	0.9830				
240.	1.0000				
250.	1.0000				
300.	1.0000				
500.	1.0000				
1000.	1.0000				

ALTITUDE	WING WEIGHT	STAGE I		BALLISTIC FACTOR IN-RANGE CROSS-RANGE	
		LAUNCH TILT	IMPACT RANGE	C.23RH	0.0103
10.	0.0	2.0	6.0	0.7488	0.0105
20.	3.0250	6.0	10.0	1.2343	0.0102
30.	0.2000	10.0	14.0	1.7017	0.0098
40.	0.4650	14.0			0.0091
50.	0.8400				
60.	1.2900				
70.	1.6500				
80.	1.7300				
90.	1.7950				
100.	1.8100				
110.	1.3050				
120.	1.7730				
130.	1.7100				
140.	1.4200				
150.	1.0000				
160.	1.0000				
170.	1.0000				

LAUNCH TILT 0.0	LAUNCH AZIMUTH C. C	IMPACT RANGE 145.9	WIND RANGE 0	PROGRAM RUN 0
TOWER SAMPLES 3	FADAR SAMPLES 0	RAWINSIDE SAMPLES 34	ONLINE PRINT 1	ITERATION PRINT 0
ALTITUDE 0.	RAWINSIDE INPUT DIRECT	SPEED		ITERATION LIMIT 0
164.0	320.	12.		
328.1	351.	21.		
492.1	376.	21.		
656.2	375.	27.		
820.2	324.	26.		
984.3	317.	29.		
1312.3	311.	31.		
164.4	310.	45.		
196.5	318.	52.		
223.6	306.	55.		
262.7	315.	65.		
295.2	304.	71.		
324.0	302.	76.		
360.8	301.	81.		
393.7	299.	78.		
426.5	296.	72.		
459.3	294.	64.		
492.1	293.	56.		
524.9	293.	47.		
557.7	294.	39.		
590.5	295.	32.		
623.3	297.	25.		
656.1	302.	20.		
688.9	309.	16.		
721.7	309.	14.		
754.5	308.	14.		
787.4	303.	16.		
820.2	299.	13.		
853.0	295.	21.		
885.8	291.	25.		
918.6	289.	29.		
951.4	286.	23.		
984.2	284.	39.		

ALTITUDE  
(FEET)

SPEED  
(KILOTS)

X VELOCITY  
(FT/SEC)

Y VELOCITY  
(FT/SEC)

Z VELOCITY  
(FT/SEC)

ACCELERATION  
(G)

ANGLE OF  
INCLINATION  
(DEGREES)

WIND SET 1

WIND SET 2

WIND SET 3

WIND SET 4

WIND SET 5

WIND SET 6

WIND SET 7

WIND SET 8

WIND SET 9

WIND SET 10

WIND SET 11

WIND SET 12

WIND SET 13

WIND SET 14

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Appendix B

EASTERN SPACE AND MISSILE CENTER (ESMC)  
ROCKET SAFETY

(AFETRM 127-1 EXCERPT  
AND  
RSOR'S 074A AND 074B, D, E)

1.2.3 Special Command Requirements. At the Range User's written request, the Range Safety Officer may implement specified functions such as "Fuel Cutoff", "Safe", or "Delayed Destruct".

1.2.4 Hazardous Systems Requirement. All hazardous missile/space vehicle systems and associated ground support equipment must be designed, tested, operated, and approved in accordance with the requirements of Chapters 3 and 5.

1.2.5 Tracking Requirements

1.2.5.1 At least two adequate and independent sources of instrumentation are required for each phase of powered flight.

1.2.5.2 At least one tracking aid compatible with Range instrumentation will be carried on all launch vehicles to improve tracking capability and data quality.

1.2.6 Range Safety Hold. A Range Safety hold will be imposed any time a condition exists that would compromise safety. In order to facilitate a hold late in the countdown, the Range Safety Officer, the Pad Safety Supervisor (PSS), and the Superintendent of Range Operations (SRO) will be provided a hold-fire capability which will stop the sequencer.

1.2.7 Impact Restrictions

1.2.7.1 No missile, space vehicle, payload, re-entry vehicle or jettisoned component will be intentionally impacted on land. Proposed flights will be planned so that normal impact dispersion areas for such items do not encompass land.

1.2.7.2 For stages that contain engines having a multiple burn capability, the impact dispersion area corresponding to any planned cutoff prior to orbital injection must be entirely over water. Trajectories must also be shaped so that impact dispersion areas

**AFETRM 127-1 Volume I 1 September 1972**

are entirely over water at times of other critical discrete events such as arming of engine cutoff circuits, and backup engine cutoff commands.

**1.2.8 Meteorological Restrictions**

1.2.8.1 When minimum Range Safety instrumentation requirements can be met, Range Safety launch clearance will not be delayed for weather solely to increase the probability of tracking.

1.2.8.2 Launch will not be permitted under weather conditions where debris, radiological material, or toxic fuel dispersions can create an unacceptable hazard to personnel.

1.2.8.3 Unguided rockets must be launched within azimuth and elevation limits established by Range Safety. Launcher azimuth and elevation restrictions must be determined from wind conditions existing at the time of launch.

1.2.8.4 The transfer and use of toxic propellants will not be permitted under weather conditions that can create an unacceptable hazard to personnel.

**1.3 APPROVALS.** There are specific mandatory approvals that the Range User must obtain in order to meet requirements of the Range. Prior to requesting an approval, a discussion of the mission with Range Safety is recommended. By so doing, data needs and requirements can be kept to a minimum.

1.3.1 Range Missile Control Flight Plan Approval. A Flight Plan Approval must be obtained prior to Range acceptance of a launch commitment. Proposed plans, together with supporting data shall be submitted as outlined in Chapter 2.

1.3.2 Missile Systems Pre-Launch Safety Approval. A Missile Systems Pre-Launch Safety Approval must be obtained prior to any hazardous pre-launch operation. Proposed plans, together with supporting data, shall be submitted to Range Safety, as outlined in Chapter 3.

X, Y, Z, and the total earth-fixed velocity relative to the pad may be substituted for  $\dot{X}$ ,  $\dot{Y}$ , and  $\dot{Z}$ . The data should be provided in time intervals no larger than 5 seconds. If trajectory data cannot be provided, the launch area pitch program and trajectory steppeness should be compared with any prior similar mission.

2.3.2.13.2 A map showing the planned vacuum locus of impact points for the intended flight azimuth or azimuth sector, and best estimates of the three sigma drag-corrected impact dispersion area for each stage, re-entry vehicle, and jettisoned component.

2.3.2.14 For space vehicles only:

2.3.2.14.1 Apogee, perigee, period, and inclination of intended orbit(s).

2.3.2.14.2 The approximate times from liftoff of discrete events such as arming or activating engine cutoff circuits, shutdown of upper stages by backup timers, firing of retro or ullage rockets, switching control functions, and shutdown of upper stages prior to orbital injection. (Discrete events must be programmed so that a simultaneous engine shutdown will not cause resulting pieces to impact on land if the vehicle is within  $\pm 3$ -sigma normal limits.)

2.3.2.15 For cruise missiles and drones:

2.3.2.15.1 If pad launched, provide the information requested in paragraph 2.3.2.13.1, page 2-8, up until cruise altitude or a cruise condition is reached.

2.3.2.15.2 A map showing the expected flight path over the earth's surface, an altitude profile correlated with the flight path, and the best estimates of the 3-sigma drag-corrected impact dispersion area for each stage, re-entry vehicle, and jettisoned component.

2.3.2.16 For small solid propellant rockets:

**AFETRM 127-1 Volume I 1 September 1972**

**2.3.2.16.1 Burn time for each stage.**

**2.3.2.16.2 Graphs of impact range vs. launch-elevation angle and ground range vs. altitude for the planned elevation angle sector.**

**2.3.2.16.3 Proposed launcher setting limits in azimuth and elevation.**

**2.3.2.16.4 Proposed flight azimuth and elevation angle limits.**

**2.3.2.17 For projectiles, torpedos, and other small thrusting devices:**

**2.3.2.17.1 Graphs of impact range vs launch-elevation angle and ground range vs. altitude for the planned elevation angle sector.**

**2.3.3 Justification and Supporting Data Requirements.**  
The Range User may be asked to provide the following additional supporting data and justification before a decision on flight plan approval can be made. The need for this information will be established in initial flight plan approval discussions or in the Range Missile Control Division response to each flight plan approval request.

**2.3.3.1 Complete statement of test objectives.**

**2.3.3.2 Statement about the test objectives which will not be met if the proposed plan must be modified as specified by the Range Missile Control Division.**

**2.3.3.3 Alternate or modified flight plans which will accomplish the test objectives.**

**2.3.3.4 Effects on the program (cost, schedule, data requirements) if the flight plan must be modified.**

**2.3.3.5 Effects on the program of modifying the proposed trajectory. (Reliability, reserve propellants, launch window.)**

for which a launching would be attempted. For any particular time after launch, approximately 99.7% of all normal vehicles (assuming a normal Gaussian distribution) will have impact ranges less than the range achieved at that time by a three sigma high-performance missile.

**2.7.6 Statement of Vehicle Performance.** Within 1 to 3 months after a missile test has been conducted, a statement of vehicle performance is required. This information may be provided by written letter or by lending the Range Missile Control Division the performance evaluation documents prepared for other purposes. Information desired includes: Qualitative statement about the performance of each stage and the various subsystems, failures which occurred and resulting flight conditions produced, probable cause of failures and corrective action taken, impact points for stages, miss distances for weapons systems tests, comparison of planned and achieved cutoff conditions for each stage, performance of onboard safety instrumentation systems.

**2.8 SMALL ROCKET DATA REQUIREMENTS**

The trajectory and performance data requirements set forth under this heading apply to all small rockets. Small rockets will not be required to carry destruct systems when dispersion analysis and control of launch conditions indicate that all vehicle components can be contained within predetermined safe areas. Lead time requirements are listed in paragraph 2.1.2.

**2.8.1 General Vehicle Data.** The following vehicle related items are required for each rocket flight or group of similar flights, and should be updated as vehicle configuration changes occur or revised information becomes available.

**2.8.1.1 General information concerning the purpose of mission, data to be obtained, number of shots in program, and a brief description of payloads giving their approximate weights.**

**AFETRM 127-1 Volume I 1 September 1972**

**2.8.1.2 Scaled diagram of vehicle.**

**2.8.1.3 The name, geodetic latitude and longitude of launch point.**

**2.8.1.4 Desired launch azimuth and launch elevation angle giving the variation in azimuth and elevation angles which are acceptable from the standpoint of mission accomplishment. Indicate which mission objectives actually determine the acceptable limits for azimuth and elevation angle.**

**2.8.1.5 A brief description of the type of launcher (e.g., zero length or short rail), travel distance of rocket to clear launcher, launcher adjustments available in quadrant elevation (QE) angle and azimuth, and the smallest increment for these adjustments.**

**2.8.1.6 Total vehicle weight and propellant weight in each stage at liftoff, and inert weight of each stage and separable component.**

**2.8.1.7 Coefficient of drag ( $C_D$ ) vs. Mach number, giving reference area (A) and weight (W) for each expended stage, separable body, and payload. Curves must cover the Mach number range from zero up through the maximum values expected. Also indicate whether bodies are stable and, if so, at what angle of attack. For pieces which can possibly stabilize during free flight, drag coefficient curves should be provided for the stability angle of attack. If the stability angle of attack is other than zero degrees, both a coefficient of lift ( $C_L$ ) vs. Mach number and  $C_D$  vs. Mach number curve should be provided.**

**2.8.1.8 Impact Dispersion Data. Three-sigma range and cross-range dispersions are required for each stage, separable component, and payload. The following factors should be considered in determining three sigma impact dispersions about the predicted impact point: Variation in thrust, error in drag estimates, thrust misalignment, fin and body misalignment, variation in weight, variation in ignition times of stages, impulse error, tip-off and separation perturbations,**

error in wind velocity measurement, error in launcher setting, and other significant perturbing influences. The 3-sigma variation in each factor must be listed in addition to the extent to which each factor displaces the impact point of each stage in downrange and crossrange directions. The total impact dispersion is then computed by a statistical combination of the individual displacements. A brief discussion of the assumptions made, method of analysis, and method of computation must be provided. The extent to which the 3-sigma impact dispersion areas change with quadrant elevation (QE) angle should also be indicated.

**2.8.1.9 Impact Prediction Data.** In most cases wind is the largest independant factor causing displacement of unguided vehicle impact points. A discussion of methods to be employed in adjusting the launcher settings to compensate for winds is required. Usually, the following data will be sufficient to predict the magnitude and direction of this effect:

**2.8.1.9.1 Ballistic wind weighting factors vs. altitude in feet.** The wind weighting factors should be presented in percent of wind effect for specific altitude intervals. The ballistic wind weighting factors should include both the effects of drift and weathercocking. Booster or first-stage wind drift effects are of prime importance since the first stage motor impact point is usually near the launch site.

**2.8.1.9.2 Change in the nominal impact point location due to missile weathercocking and drift as a result of ballistic winds (head, tail, side, or resultant wind effect).** The deviation should be provided in feet or nautical miles per foot per second of wind. Since deviations vary significantly with a change in launcher quadrant elevation (QE) angle, values must be supplied in a table of launcher QE vs. unit wind effect. The table must have a minimum interval of 2 degrees and include the range of elevation angles for which launches are to occur.

**2.8.1.9.3 Launcher adjustment curve or launcher tilt effect to correct the launcher in azimuth and elevation for wind effects.**

AFETRM 127-1 Volume I 1 September 1972

**2.8.1.10 Launch Aircraft Data:** For air-launched rockets, the data items in paragraph 2.7.1.18 for Cruise Missiles should be provided.

**2.8.1.11 Summary of past vehicle performance** giving number launched, launch location, number which performed normally, behavior and impact location for any which malfunctioned, nature of malfunction, and corrective action.

**2.8.2 Trajectory Requirements.** The trajectory data items in paragraphs 2.8.2.1 through 2.8.2.4 are required from launch until burnout of the final stage for each desired nominal quadrant elevation angle and payload weight. These items must be provided in a tabular form as a function of time with each column of the table containing only a single parameter. Time must be given at even intervals, not to exceed one second increments during thrusting flight, and for times corresponding to ignition and thrust termination or burnout of each stage. If stage burning times are less than 4 seconds, time intervals should be reduced to .2 second.

**2.8.2.1 Velocity** (ft/s) vs. time of flight (s).

**2.8.2.2 Altitude** (ft) vs. time of flight (s).

**2.8.2.3 Ground range** (ft) vs. time of flight (s).

**2.8.2.4 Flight path angle of the total velocity vector** (deg) vs. time of flight (s).

**2.8.2.5** In addition to the tabular nominal trajectory data, graphs of the following are required for each stage. A separate set of graphs should be provided for each payload weight.

**2.8.2.5.1 Impact range** vs. launch elevation angle (mi or ft vs. deg).

**2.8.2.5.2 Apogee altitude vs launch elevation angle** (ft vs. deg).

**2.8.2.5.3 Ground range vs. altitude** (mi or ft vs. ft).

**2.8.3 Statement of Vehicle Performance.** Within 1 to 3 months after a vehicle test has been conducted, a statement of vehicle performance is required. This information may be provided by written letter or by lending the Range Missile Control Division the performance evaluation documents prepared for other purposes. Information desired includes: Qualitative statements about the performance of each stage and the various subsystems, failures which occurred and resulting flight conditions produced, probable cause of failures and corrective action taken. In addition, the following data are required:

**2.8.3.1** Vehicle type and number, launch date, launch location, test number, payload type and weight.

**2.8.3.2** Actual launcher azimuth and elevation setting (deg).

**2.8.3.3** Predicted range (nmi) and azimuth (deg) from the launcher to the impact point for each stage and payload. The predicted range and azimuth should be based upon the predicted winds at time of launch.

**2.8.3.4** Actual range (nmi) and azimuth (deg) from the launcher to the impact point for each stage and payload.

**2.8.3.5** Actual impact range components (nmi) for each stage and payload measured along and perpendicular to the predicted impact azimuth. Where a stage is not tracked to impact, the impact point should be computed using the best estimates of the drag characteristics and of the winds at launch.

**2.8.3.6** Predicted effective QE (deg) of trajectory for each stage.

**2.8.3.7** Actual effective QE (deg) of trajectory for each stage.

**2.8.3.8** Predicted range (nmi) and altitude (ft) of apogee for each stage.

**2.8.3.9** Actual range (nmi) and altitude (ft) of apogee for each stage.

**AFETRM 127-1 Volume I 1 September 1972**

**2.8.3.10 A tabulation of the reduced wind data used to make the launcher setting calculations giving speed (ft/s) and direction (deg) as a function of altitude (ft).**

**2.8.3.11 A reference list of all documents, graphs and tabulations which were used in making the launcher setting calculations, i.e., wind weighting curves, ballistic wind weighting factors, unit wind effect.**

**2.8.3.12 Source of tracking data.**

**2.9 AIR-DROPPED INERT BODY/PROJECTILE/TORPEDO/ SMALL DEVICE DATA REQUIREMENTS**

The data requirements set forth under this heading are designed primarily for nonpropulsive bodies dropped ballistically or by parachute from aircraft. Depending on the nature of the object being tested, the Range Missile Control Division may require additional data not required in this section. Data lead time requirements are listed in paragraph 2.1.2.

**2.9.1 General Vehicle Data.** The following items are required for each test or group of similar tests, and should be updated as the test object configuration changes or as revised information becomes available.

**2.9.1.1 General information concerning the purpose of the test, data to be obtained, description of object(s) to be tested, number of tests in the program, and proposed testing dates.**

**2.9.1.2 Scaled diagram of vehicle.**

**2.9.1.3 Latitude and longitude of the desired drop or launch point and impact or target point.**

**2.9.1.4 Coefficient of drag ( $C_D$ ) vs. Mach number, giving reference area (A) and weight (W) for each object(s) being dropped or tested. If the body descends on a parachute or other device, drag data both before and after chute opening must be provided.**

RANGE SAFETY OPERATIONS REQUIREMENT NO. 074A

LOKI LAUNCH

STATION 1

5 November 1973

APPROVED:

  
HARVEY TAFFET, Lieutenant Colonel, USAF  
Chief, Range Missile Control Division  
Directorate of Range Operations

ACCEPTED:

  
MARTIN H. BREWER, Colonel, USAF  
Chief, Test Operations Division  
Directorate of Range Operations  
NOV 9 1973

5 November 1973      RANGE SAFETY OPERATIONS REQUIREMENT    NO. 074A

1. Introduction: The requirements stated herein apply to all LOKI rockets launched from CKAFS under the provisions of OD 074A except in those instances where specific requirements are waived by the Chief, Range Missile Control Division, Directorate of Range Operations (DON).

1.1 The provisions of section E, AFETRM 127-1, 1 January 1969, will apply except as indicated in the paragraphs that follow.

2. Documentation: No change

3. Explanation of Terms:

Add:

3.1 The Launch Danger Area includes the land area within 3750 feet of the launch pad.

3.2 The Blast Danger Area is the area within 100 feet of the launch pad.

3.3 The Launch Area (Sea) is the ocean area within 3750 feet of the launch pad and the ocean area between true azimuths 045° and 135° and tangent to a circle of 3750 feet radius centered at pad out to a distance of 3 nautical miles.

3.4 The Metro Rocket Area is that area bounded on the North from 28°42'N 80°35'W to 29°N 79°30'W, on the east by longitude 79°30'W and on the south from 28°00'N 79°30'W to 28°00'N 80°00'W to 28°22'N 80°33'W.

4. Instrumentation: N/A

Substitute:

- 4.1 Data Requirements:

The Range Contractor should provide the following data to the Range Safety Division (DON) by F + 14 days. When radars are not required in direct test support of higher priority missile launches, they will be used to meet the data requirements in paragraphs 4.1.4, 4.1.5 and 4.1.9. On all tests, items not requiring radar will be provided to DON.

5 November 1973      RANGE SAFETY OPERATIONS REQUIREMENT NO. 074A

- 4.1.1 Missile type and number, launch date, launch location, test number, payload type and weight.
  - 4.1.2 Actual launcher azimuth and elevation setting (deg).
  - 4.1.3 Predicted range (nmi) and azimuth (deg) from the launcher to the impact point for each stage. The predicted range and azimuth should be based upon the predicted winds at time of launch.
  - 4.1.4 Actual range (nmi) and azimuth (deg) from the launcher to the impact point for each stage.
  - 4.1.5 Actual impact range components (nmi) for each stage measured along and perpendicular to the predicted impact azimuth. Where a stage is not tracked to impact, the impact point should be computed using the best estimates of the drag characteristics and of the winds at launch.
  - 4.1.6 Predicted effective quadrant elevation (QE) (deg) of trajectory for each stage.
  - 4.1.7 Actual effective QE (deg) of trajectory for each stage.
  - 4.1.8 Predicted range (nmi) and altitude (ft) of apogee for each stage.
  - 4.1.9 Actual range (nmi) and altitude (ft) of apogee for each stage
  - 4.1.10 A tabulation of the reduced wind data used to make the launcher setting calculations giving speed (ft/sec) and direction (deg) as a function of altitude (ft).
  - 4.1.11 A reference list of all documents, graphs and tabulations which were used in making the launcher setting calculations, i.e., wind weighting curves, ballistic wind weighting factors, unit wind effect, tower tilt factors, etc.
  - 4.1.12 Source of tracking data.
- 5. Real-Time Impact Prediction System: N/A
  - 6. Missile Flight Termination System: N/A
  - 7. Timing and Sequencer: N/A

5 November 1973      RANGE SAFETY OPERATIONS REQUIREMENT    NO.    074A

8. Launch Area Surveillance:

Delete: paragraphs 8.3.1, 8.3.2 and 8.5

9. Plotting Boards: N/A

10. Television: N/A

11. Communications:

Substitute:

11.1 Communications will be specified by the Superintendent of Range Safety (SRO) to accomplish this function.

12. Motion Picture Coverage: N/A

13. Specific Duties, Reports, and Responsibilities of Range Personnel:

Add:

13.4 The SRO will act for the Range Safety Officer (RSO) in performing functions under this paragraph.

14. Weather Forecast Requirements:

Substitute:

14.1 The effective QE will be not less than 78° nor greater than 85°. The launcher elevation setting will be not less than 76° nor greater than 88°.

14.2 Launch azimuth will be as follows:

14.2.1 If the effective QE is equal to or greater than 83°, the effective launch azimuth will be not less than 65° true, nor greater than 120° true.

14.2.2 If the effective QE is less than 83°, and there are Navy vessels operating in their area, the effective launch azimuth will be between 56° and 63° true or between 108° and 120° true.

5 November 1973

RANGE SAFETY OPERATIONS REQUIREMENT NO. 074A

- 14.2.3 If the effective QE is less than 83°, and there are no Navy vessels operating in their area, the effective launch azimuth will be not less than 65° true nor greater than 120° true.
- 14.2.4 The azimuth setting will be not less than 45° nor greater than 135° true.
- 14.3 The ballistic wind used to establish the launcher settings must consider at least 85 percent of the effective wind and must be the best prediction of winds at launch determined from winds obtained less than 1 hour prior to launch.
- 14.4 The following illustration establishes the hazards to shipping in the impact area. If these limits are adhered to, the total probability of ship impact will not exceed 1/100,000 or ( $10^{-5}$ ).
- 14.4.1 The ship impact probabilities circles shown in paragraph 14.4.2 should be centered at the predicted impact point of the Dart. The ranges to these impact points are:

<u>Effective QE</u>	<u>Range (Nautical Miles)</u>
78	31.5
79	29.0
80	26.5
81	23.5
82	21.5
83	19.0
84	16.0
85	13.5

- 14.4.2 Launch is permitted if the sum of the products of (number of ships) x (factor (f)) of their respective shells (as shown below) does not exceed 1.0.

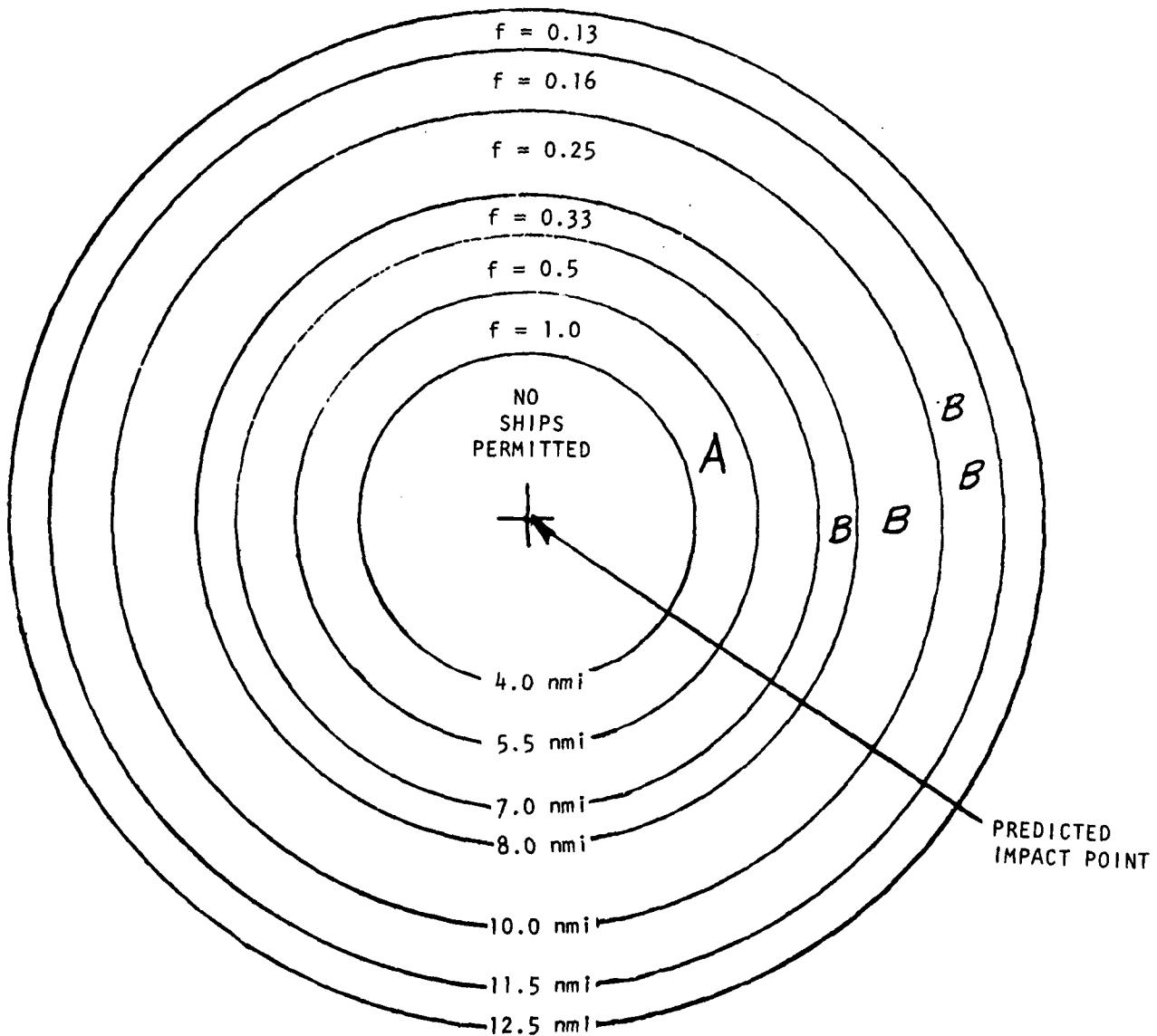
5 November 1973

RANGE SAFETY OPERATIONS REQUIREMENT

OD 074A

Examples:

- a. One ship A located as shown:  
 $(\text{number of ships})(f) = 1 \times 1 = 1.0$ , launch permitted.
- b. Four ships B located as shown:  
 $(\text{number of ships})(f) = (2)(.16) + (1)(.25) + (1)(.33)$   
= .9, launch permitted.



5 November 1973      RANGE SAFETY OPERATIONS REQUIREMENT   NO. 074A

- 14.5 The ballistic wind used to establish the launcher settings must consider at least 85 percent of the effective wind, and must be determined from winds obtained less than 1 hour prior to launch.
- 14.6 Launch will not be permitted if the predicted impact point of the motor case is west of a north-south line located 1000 feet west of the launcher.

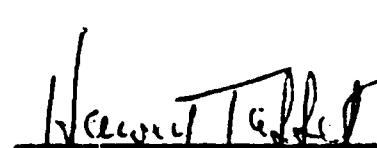
RANGE SAFETY OPERATIONS REQUIREMENT NO. 074, B, D, E

SUPER LOKI

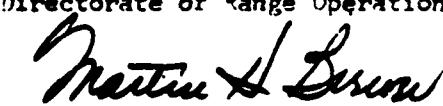
STATION 1

5 November 1973

APPROVED:

  
HARVEY TAFNIT, Lt Colonel, USAF  
Chief, Range Missile Control Division  
Directorate of Range Operations

ACCEPTED:

  
MARTIN H. BREWER, Colonel, USAF  
Chief, Test Operations Division  
Directorate of Range Operations

AM 9 1973

5 November 1973      RANGE SAFETY OPERATIONS REQUIREMENT NO. 074, B, D, E

1. Introduction: The requirements stated herein apply to all SUPER LOKI rockets launched from CKAFS under the provisions of OD 074, B, D, and E except in those instances where specific requirements are waived by the Chief, Range Missile Control Division, Directorate of Range Operations (DON).

- 1.1 The provisions of section E, AFETRM 127-1, 1 January 1969, will apply except as indicated in the paragraphs that follow.

2. Documentation: No change

3. Explanation of Terms:

Add:

3.1 The Launch Danger Area includes the land area within 3750 feet of the launch pad.

3.2 The Blast Danger Area is the area within 100 feet of the launch pad.

3.3 The Launch Area (Sea) is the ocean area within 3750 feet of the launch pad and the ocean area between true azimuths 075° and 120° and tangent to a circle of 3750 feet radius centered at pad out to a distance of 3 nautical miles.

3.4 The Metro Rocket Area is that area bounded on the North from 28°42'N 80°35'W to 29°N 79°30'W, on the east by longitude 79°30'W and on the south from 28°00'N 79°30'W to 28°00'N 80°00'W to 28°22'N 80°33'W.

4. Instrumentation: N/A

Substitute:

- 4.1 Data Requirements:

The Range Contractor should provide the following data to the Range Safety Division (DON) by F + 14 days. When radars are not required in direct test support of higher priority missile launches, they will be used to meet the data requirements in paragraphs 4.1.4, 4.1.5 and 4.1.9. On all tests, items not requiring radar will be provided to DON.

4.1.1 Missile type and number, launch date, launch location, test number, payload type and weight.

4.1.2 Actual launcher azimuth and elevation setting (deg.).

- 4.1.3 Predicted range (nmi) and azimuth (deg) from the launcher to the impact point for each stage. The predicted range and azimuth should be based upon the predicted winds at time of launch.
  - 4.1.4 Actual range (nmi) and azimuth (deg) from the launcher to the impact point for each stage.
  - 4.1.5 Actual impact range components (nmi) for each stage measured along and perpendicular to the predicted impact azimuth. Where a stage is not tracked to impact, the impact point should be computed using the best estimates of the drag characteristics and of the winds at launch.
  - 4.1.6 Predicted effective quadrant elevation (QE) (deg) of trajectory for each stage.
  - 4.1.7 Actual effective QE (deg) of trajectory for each stage.
  - 4.1.8 Predicted range (nmi) and altitude (ft) of apogee for each stage.
  - 4.1.9 Actual range (nmi) and altitude (ft) of apogee for each stage.
  - 4.1.10 A tabulation of the reduced wind data used to make the launcher setting calculations giving speed (ft/sec) and direction (deg) as a function of altitude (ft).
  - 4.1.11 A reference list of all documents, graphs and tabulations which were used in making the launcher setting calculations, i.e., wind weighting curves, ballistic wind weighting factors, unit wind effect, tower tile factors, etc.
  - 4.1.12 Source of tracking data.
5. Real-Time Impact Prediction System: N/A
  6. Missile Flight Termination System: N/A
  7. Timing and Sequencer: N/A
  8. Launch Area Surveillance:  
Delete: paragraphs 3.3.1, 8.3.2 and 8.5
  9. Plotting Boards: N/A
  10. Television: N/A

11. Communications:

Substitute:

- 11.1 Communications will be specified by the Superintendent of Range Safety (SRO) to accomplish this function.

12. Motion Picture Coverage: N/A

13. Specific Duties, Reports, and Responsibilities of Range Personnel:

Add:

- 13.4 The SRO will act for the Range Safety Officer (RSO) in performing functions under this paragraph.

14. Weather Forecast Requirements:

Substitute:

- 14.1 The effective flight azimuth will be 90°. The launcher azimuth settings will be between 075° and 105°T.

- 14.2 The effective QE will be 80°. The launcher elevation settings will be between 76° and 84°.

- 14.3 The ballistic wind used to establish the launcher settings must consider at least 85 percent of the effective wind and must be determined from winds obtained less than 1 hour prior to launch.

- 14.4 The following information establishes the hazards to shipping in the impact areas. If these limits are adhered to the total probability of ship impact will not exceed 1/100,000 or ( $10^{-5}$ ).

- 14.4.1 Launch is not restricted for ships operating in the NOTU area under OD 211.

- 14.4.2 As a result of the deletions in paragraph 8, surveillance is required only in the launch areas. However, if ship locations in the impact area are known as a result of schedule or other means, the following is applicable.

- 14.4.2.1 No more than nine ships are permitted within an ellipse centered at the predicted impact point with a major axis of 55 nautical miles along the flight azimuth and a minor axis of 10 nautical miles. Of these, no more than two are permitted within an ellipse centered at the predicted impact point with a major axis of 28 nautical miles along the flight

5 November 1973    RANGE SAFETY OPERATIONS REQUIREMENT    NO. 074, B, D, E

azimuth and a minor axis of 5 nautical miles. The predicted impact range for the Dart is 45 nautical miles for an effective QE of 80°.

- 14.6 Launch will not be permitted if the predicted impact point of the motor case is west of a north-south line located 1000 feet west of the launcher.

**Appendix C**

**WHITE SANDS MISSILE RANGE (WSMR)  
ROCKET SAFETY**  
**(METEOROLOGICAL SUPPORT OPERATIONS  
AND  
EXCERPT FROM WSMR USERS HANDBOOK)**

WHITE SANDS MISSILE RANGE (WSMR)  
ROCKET SAFETY

1. The initial responsibility for determining unguided small rocket launcher settings at White Sands Missile Range (WSMR) is delegated by the Flight Safety Branch to the Meteorological Support Division Met Team of the Atmospheric Sciences Laboratory (ASL). Final launcher settings are verified by a responsible second party and ultimately reviewed by the Missile Flight Test Safety Manager (MFTSM) prior to missile launch. Anticipated impacts and launcher settings are recorded and a red/green light verification made. A "green" is granted provided hard impacts of debris are contained within a 2-sigma safe designated area of the range and soft impact of all test items well within the Continental United States (CONUS) is ensured.
2. The Met Support Team derives launcher settings through the use of project provided aerodynamic and ballistic data on the missile, standard range atmospheric data for the month of launch, and real-time data provided by tower winds (0-500 feet) and 30-gram aluminum wrapped balloon track by T9 radar. An HP-97 model is used to arrive at launcher settings with a five-degree-of-freedom model to verify desired impact.
3. WSMR also launches National Aeronautical and Space Administration (NASA) unguided rockets with sufficient performance capability to impact off range. These systems require a flight termination system (FTS) to perturb ballistic flight as necessary to prevent off-range impact, real-time flight safety test management support as well as a more elaborate meteorological procedure. For these launches, besides the above described tower and balloon tracks, high altitude (8-100,000 feet) radiosonde observation (RAOB) balloon track by FPS-16 is required at T-3 hours, T-75 minutes, and T-45 (partial track) plus

an additional track beginning at T-0. For vehicles with a very high altitude burnout, such as Astrobee-F, a LOKI track may be required at T-4 hours for additional upper atmosphere winds. This serves to reduce main body dispersion by an additional 6 percent.

4. At specific intervals during the real-time coutndown, the Meteorological Team provides variability information. At approximately T-10 minutes a confidence level for impact in the desired mile area is provided. The MFTSM then, based on this information, plus a valid FTS verification, and confirmation of evacuation/roadblock in place, goes "green" for missile launch.

5. WSMR missile flight safety has the capability to require call up of additional land areas to the west and/or to the north of the range. For test experiments requiring apogees above 150 statute miles, these areas are required to reduce risk to test due to larger debris dispersions and uncertainties in winds.

METEOROLOGICAL SUPPORT OPERATIONS  
AT  
WHITE SANDS MISSILE RANGE, NEW MEXICO

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ABSTRACT

White Sands Missile Range (WSMR), New Mexico, a national missile range, operated by the U.S. Army, is engaged in research, development, and test and evaluation activities involving a variety of ballistic and guided missile systems, research sounding rockets, and other research efforts.

Requirements for meteorological data collection, climatological data, and specialized weather forecasts are discussed. Techniques and instrumentation for providing these data include the conventional, unconventional, and the unique. The role of the WSMR Meteorological Team of the Atmospheric Sciences Laboratory (ASL), U.S. Army Electronics Command, providing these services is described.

METEOROLOGICAL SUPPORT OPERATIONS  
AT  
WHITE SANDS MISSILE RANGE, NEW MEXICO

1. INTRODUCTION

The mission of the Atmospheric Sciences Laboratory (ASL) WSMR Meteorological (Met) Team is to provide complete meteorological support for WSMR.

Almost all activities on WSMR require some meteorological support. The atmosphere is constantly changing; and these changes affect missile performance, radar and optical systems, telemetry systems, etc., used and being tested on the range.

Meteorological measurements made during the tests are essential to the evaluation of various test programs. Some of the major functions in furnishing meteorological support for the range operations and for the test programs of the range users are:

- a. Meteorological data collection
- b. General and specialized weather forecasts
- c. Severe weather warnings
- d. Climatological data
- e. Ballistic meteorological services including impact prediction of unguided rockets
- f. Sonic Observations of Trajectory and Impact of Missiles (SOTIM)
- g. Meteorological consultation services
- h. Operation, development and maintenance of electronic meteorological systems and digital interface equipment.

Each of these functions will be discussed in detail later. WSMR is highly instrumented and is the only national land range operated by the U.S. Army in the support of research, development, testing, and evaluation of a variety of systems and projects, including atmospheric research.

2. ORGANIZATION

To accomplish its mission and meet its support requirements, the WSMR Met Team is organized into several units with a total authorized strength of 139 personnel (36 civilians and 103 military). The Meteorological Coordination and Scheduling Unit schedules all meteorological support activities in support of scheduled range missions and coordinates meteorological support activities between National Range Operations and supporting elements.

The Electronics Unit installs, tests, operates, and maintains meteorological instrumentation and equipment required by the Met Team.

The Engineering Unit develops and recommends detailed plans for new equipment and modifications for existing meteorological equipment in use by the Met Team.

The Data Reliability Unit checks all data obtained by the different sections of the Met Team for reliability and completeness and then distributes the final data to range users.

Meteorological technicians, team supervisors, and quality control center personnel use intensive verification procedures to maintain a high level of quality control of all meteorological data before the data are forwarded to the computer centers for reduction.

The Forecast Unit operates a 24-hour meteorological surface observation station and provides meteorological forecast support for WSMR. Included in its support are many routine and specialized forecasting services tailored to the user's needs for such projects as missile testing, aircraft flights, sphere drops, and sounding rockets.

### 3. METEOROLOGICAL DATA COLLECTION

WSMR is a highly instrumented missile range. The range is approximately 40 by 100 miles. Additional land space required for tests of higher performance missiles is made available through co-use land. Over this vast expanse of land, the Met Team collects meteorological data at permanent and mobile sites. These data consist of both surface and upper air observations of existing atmospheric conditions as required by users. High-altitude meteorological data (80-250K feet) is gathered by meteorological rocket soundings.

WSMR is more highly instrumented for the study of atmospheric conditions than any other comparable area in the United States. Several well-instrumented meteorological towers and surface and upper air sites located on the range provide means for conducting research on atmospheric motion over various types of terrain. Wind, temperature, pressure, and moisture data are routinely collected to 60 kilometers by six rawinsonde stations and one meteorological rocket site. WSMR is believed to be the only area in the world where meteorological data are routinely available from the surface to 110 kilometers. During 1975 there were 2911 radiosonde observations (RAOB's)/ rawin flights completed on WSMR from the six rawinsonde stations. Data are collected by using surface observations, rawinsonde observations, pilot balloon (PIBAL) techniques, and a meteorological rocket unit which launches meteorological rockets to obtain high-altitude data both for range support and the Meteorological Rocket Network (MRN).

Support provided includes:

- a. Surface observations on a 24-hour per day 7-day per week basis and special observations as warranted are taken and recorded at the Headquarters Weather Station (A-Station) and from 0800-1600 LST at White Sands Desert (WSD) Site near LC-33, Holloman Air Force Base, and the Stallion Range Center.

b. Upper-Air Observations. These observations can be separated into three categories: (1) rawinsonde, (2) meteorological rockets, and (3) pilot balloon (PIBAL).

(1) Rawinsonde. This equipment provides a means of measuring temperature, pressure, and wind direction and speed to approximately 100,000 feet mean sea level (MSL), and humidity data to approximately 35,000 feet MSL. Routine rawinsonde observations are made twice daily from the WSD Meteorological Site at 0200 and 0900 LST, Monday through Friday; from the Holloman AFB Meteorological Site at 0200 and 0800 LST, Monday through Friday, and also at 0200 on Saturday and Sunday; and once daily from the Stallion Meteorological Site between 0900 and 1200 LST, Monday through Friday. The Met Team also maintains permanent rawinsonde sites at the Small Missile Range (SMR), Apache Site and Jallen (Rhodes Canyon) Site, recent addition at Fort Bliss Dona Ana Range camp and four mobile units for on range and off range. Any or all 11 rawinsonde units can be scheduled for mission support at any time of the day.

(2) Meteorological Rocket Observation. These rockets provide a means for obtaining high-altitude meteorological data from 80,000 to above 200,000 feet MSL. Meteorological rockets are launched from the SMR complex. Meteorological rockets are fired routinely from the SMR site at 1200 LST every Monday, Wednesday and Friday and any time of day or night, as required for mission support. The meteorological rockets are equipped with radar-reflective parachutes which may be tracked by radar to provide derived wind data, the only data obtained with this configuration. Other types of rocket payloads include temperature and ozone sensors and telemetry systems. Inflatable Robin spheres are tracked on a routine basis for high-altitude density and wind measurements.

(3) Pilot Balloon (PIBAL). The three methods of PIBAL observations employed at WSMR include single theodolite (S/T), double theodolite (D/T), and radar automatic PIBAL tracking system (RAPTS T-9 or T-9 radar).

(a) Single theodolite (S/T) method is used to obtain windspeed and direction from the surface to about 10,000 feet above the surface. This system is highly mobile, but the least accurate of the three methods.

(b) Double theodolite (D/T) method is used to obtain windspeed and direction but is limited to heights equal to  $2\frac{1}{2}$  times the baseline. Baselines presently being used are 1,000, 2,000, 4,000, and 6,000 feet.

(c) RAPTS T-9 is used to obtain windspeed and direction to heights of up to 12,000 feet (heights to 30,000 feet may be obtained with ideal conditions). The WSMR Met Team presently has seven permanent and five mobile T-9 radar units assigned for mission support.

c. Ionospheric observations are obtained from a C3/4 ionosonde recorder and field intensity chart recorders. Ionosphere observations are taken 24 hours daily and special reduction of data can be provided to range users as required.

d. Meteorological Towers. Two 500-foot fully instrumented meteorological towers and one 200-foot meteorological tower are currently used on WSMR in support of missions. The 500-foot towers are located at LC-35 and LC-36, and the 200-foot tower is located at LC-33. Another 500-foot meteorological tower is located at the Utah Launch Complex (ULC), Green River, Utah, and is available for long-distance launches.

e. Fixed Pole Anemometers. There are numerous fixed pole anemometers located as high as 125 feet above the surface at various launch complexes and at special user areas.

f. The WSMR Met Team utilizes a 3-centimeter TPS-41 radar located at Oasis Site approximately 10 miles east of Post Headquarters. The radar is extensively used during the summer months for thunderstorm tracking and forecasting. This radar possesses an iso-echo contouring feature and has also been successfully used for tracking chaff clouds.

#### 4. WEATHER FORECASTS

The Weather Forecast Unit provides general and special weather forecasts for all meteorological parameters required by programs operating at WSMR. Parameters forecast routinely at 0800 and 1400 daily include: cloud types, amount in levels, and heights above ground in feet; visibility and restrictions to visibility in miles; public worded weather forecast for 48 hours at WSMR and recorded on telephone; turbulence (type, location, duration, and altitude); height of the freezing level; surface winds (direction, mean velocity, and peak gusts); maximum and minimum temperatures; and 72-hour general outlook. In addition, winds aloft are forecast along with ambient air temperatures every 5,000 feet from the surface through 100,000 feet MSL.

Specialized weather forecasts are specifically tailored to the individual user's needs and involve such parameters as winds aloft to 200,000 feet MSL for high-altitude constant level balloons; D-values and altimeter setting forecasts for aircraft; density altitude for helicopter operations; icing areas in clouds for drone operations, likelihood of contrail formation; index of refractions for radar operations, parachute and balloon drifts for safety, evaluation, and recovery purposes; artillery meteorological messages for aiming correction purposes; nuclear fallout predictions, etc.

#### 5. SEVERE WEATHER WARNINGS

Severe weather warnings are issued when weather conditions are expected that may endanger life or property or which might jeopardize successful completion of range missions. Weather warnings are issued for thunderstorms with hail, lightning, or strong wind gusts; icy roads, heavy snow, wind gusts over 30 knots, tornadoes, and dust storms with low visibilities. Weather warnings have nearly a 90 percent verification rate for the missile range.

#### 6. CLIMATOLOGY

Many thousands of meteorological observations, both surface and aloft, are made within the confines of WSMR and at off-range locations. Because of the

high density of observations, particularly rawinsonde, many research opportunities are offered which could not be accomplished at other locations without special expenditures of time, money, and manpower. Analysis of these data has provided unusually complete studies of WSMR atmospheric conditions. These studies are available for use by WSMR users and other interested agencies. The following climatology is available for each rawinsonde in published form: monthly tabulations of means and extremes from the surface to 100,000 feet MSL of wind direction and velocity, temperature, pressure, dewpoint, relative humidity, freezing level height, density, and index of refraction for a 13-year period of record.

Climatology for A-Station (headquarters) is available in published form for a 26-year period of record. The following parameters are available by hour and by month (means and extremes are included): wind direction and velocity including peak gusts, sky cover, amounts and heights, temperature, relative humidity, dewpoint, pressure, visibility, and weather occurrences.

#### 7. UNGUIDED ROCKET IMPACT PREDICTION

The ballistic meteorological services consist of the analysis of theoretical unguided rocket performance, atmospheric effects upon rocket performance, and determination of launcher settings which will satisfy project requirements of trajectories and impact points for the various stages. "Impact prediction" is the term applied to the service provided just before rocket launch. A major feature is that the ballistics meteorologist who performs this function provides the test conductor with launcher settings which will compensate for the wind effect and allow the launch of an unguided rocket into the desired trajectory and impact area. The launcher settings provided are based upon application of timely wind measurements in the operational area and on forecasting expertise. Calculations of launcher settings and the prediction of rocket impact are mandatory before the missile flight safety officer will permit the firing of many types of rockets at WSMR. Flight safety "hold" determinations are based on meteorological impact predictions and assessments of the variability due to the windspeed for all but the very short-range unguided rockets which cannot exceed range boundaries. These impact predictions involve thorough and accurate measurements and analysis of wind conditions through predetermined layers of the atmosphere.

Real-time impact predictions developed and applied by meteorological support personnel are performed at WSMR when highly wind-sensitive rockets are launched. This system uses a high-speed computer (UNIVAC 1108) with wind data inputs on a real-time basis from instrumented towers and radar tracks of balloons and/or parachutes. This system provides highly timely and accurate measurements. Examples of missions requiring real-time support are high-altitude research vehicles such as the Aerobee 350, Black Brant, and Astrobee-F. Real-time procedures require ballistics meteorological services at the launch points for verification of wind data inputs to the computer and the assessment of the overall wind variability situation, and also at the computer for validation of computed layer winds and derived launcher settings.

Low-level wind field measurements for real-time application are obtained from 500-foot towers instrumented at eight levels, with local analog plots and

digital sampling at five per second, and from the T-9 Automatic PIBAL Tracking System, with local analog plots and digital sampling at 20 per second. All digital data are formatted and transmitted to a high-speed digital computer for processing. Upper-level wind data to altitudes above 200,000 feet MSL are obtained from either of two systems. One method employs real-time computer input of FPS-16 radar tracking data from a balloon-borne ascending target and from a descending target carried aloft by a meteorological rocket. The second method obtains wind data through standard rawinsonde techniques and manual reduction of the information obtained from the radar track of the rocket-borne target. Application of wind data to a trajectory simulation produces a launcher setting which will compensate for the existing wind field to achieve desired project goals. Computer output also includes predicted trajectory velocity vectors, velocities, and space points as functions of time, which are presented to project personnel and to the missile flight safety officers for performance evaluation during the missile flight.

For the field technique of impact prediction, weighting factors are applied to measured winds, and compensating launcher settings are determined by using missile response characteristics derived from theoretical trajectory simulations.

In either system, firm firing recommendations (go or no-go) are presented by the ballistics meteorologist (impact predictor) to the project officer, the WSMR range controller, and the missile flight safety officer. This recommendation includes the probability of the successful achievement of the mission objectives under existing and predicted atmospheric conditions.

The Forecast Unit has provided impact prediction at numerous sites on WSMR and also at Green River, Utah; Poker Flats, Alaska; Fort Churchill, Canada; Woomera, Australia; Wake Island (Pacific Ocean); and Fort Wingate, New Mexico. These impact predictions have served the National Aeronautics and Space Administration (NASA), the U.S. Army, the U.S. Air Force, the U.S. Navy, the U.S. Defense Nuclear Agency (USDNA), various private agencies, and universities using the missile ranges. Payloads on these rockets have varied from tactical weapons to spectrometers used in astronomy.

Some of the multitude of rockets for which impact predictions have been performed are: Aerobees (150, 170, 200, 350), Pershing (booster only), Aries, Loki, Quanah, Athena, Black Brant, Ute Tomahawk, and Nike Apache.

The wind effect in the first 500 feet is very critical with a high percentage of the overall effect for most rockets. At 60 to 90 seconds before launch, limits are plotted on a Cartesian plotter display of real-time tower wind effect. These limits are based on changes in the wind since the final launcher settings were selected and are used by the impact predictor as his final decision of go versus no-go for a given launch. Impact prediction blends a knowledge of both meteorology and aerodynamics. When feasible (and in accordance with range scheduling), missile launches are scheduled in accordance with the latest weather forecasts to prevent costly cancellations due to adverse weather.\* A knowledge of the forecast jet stream

\*Present Aerobee support costs approximately \$1,000 per minute for a 3-hour support.

position can be very useful in choosing the level of second-stage ignition for two-stage sounding rockets.

Before each launch, the Forecast Unit runs a mathematical trajectory simulation for each rocket. Input includes weight, thrust, center of gravity, inertia, nozzle exit area versus time, drag coefficients, normal force coefficients, centers of pressure, pitching moment of inertia and coefficient, reference area, and reference length versus Mach number for each phase of the rocket flight, along with initial launch conditions and atmospheric parameters.

Sonic Observation of the Trajectory and Impact of Missiles (SOTIM) is a completely passive acoustical system for detecting shock waves generated by objects moving through the atmosphere at velocities greater than the speed of sound. Data relative to these shock waves are analyzed to derive information from portions of the trajectory of the object as well as the impact point. Each site consists of four microphones installed at the corners of a 1,000-foot square oriented on true north. Because of the accuracy and reliability of the system, many valuable missiles and missile payloads have been recovered.

SOTIM provides a complement to radar impacts of the rockets.

#### 9. CONSULTATION SERVICES

Professional meteorological consultation services are provided to test officers requiring meteorological support services at WSMR or to those planning to utilize WSMR facilities for future RDT&E programs. These consultant services generally cover the entire scope of meteorology - atmospheric effects, techniques of applying meteorological data, instrumentation available for data collection, and recommendations for the data and techniques useful to any particular project.

Some of the multitude of special meteorological projects the Forecast Unit engages in are: the U.S. Air Force Cruise Missile Program, selected climatological data to WSMR Facilities Engineering Directorate; solar, lunar angle data and meteorological data and forecasts to the Nuclear Effects Laboratory and Solar Furnace on WSMR; unguided sounding rocket dispersion studies, and temperature inversion data for air pollution studies for the Texas Air Quality Control Board.

The meteorologists of the Forecast Unit in their consulting capacity have authored various meteorological publications that are readily available to range users.

Assisting the meteorologists in their consultations are a myriad of computer programs written by the meteorologists of the Forecast Unit. The Forecast Unit has a remote terminal to the WSMR UNIVAC 1108 computer. In addition, Nova miniprocessors are used along with Wang programmable calculators.

#### 10. INSTRUMENTATION AND TECHNIQUES

Many of the meteorological systems employed at WSMR are age-proven, such as the Ground Meteorological Device (GMD) rawinsonde set, the 500-foot tower

with multilevel sensing, the meteorological rocketsonde, and the surface observing equipment. Much productive effort has been made by ASL elements in the development and improvement of meteorological rocket hardware, data knowledge, and techniques. Equally as important is the investigative effort in the area of low-level wind field characteristics as this has influenced the processing techniques and produced improved meteorological support to projects.

One system developed by ASL is the T-9 Automatic PIBAL Tracking System, which uses the radar (T-9) from the T-38 Fire Control System (antiaircraft). The T-9 radar, operating at 3-centimeters wavelength and 40-kilowatts peak power, has a maximum tracking range of 26,000 yards. In application, the radar tracks a balloon-borne shaped-aluminum-foil target and will consistently obtain wind data to more than 10,000 feet above ground when average wind-speeds are 30 to 40 miles per hour or less. The T-9 system uses synchro-to-digital converters for range, azimuth, and elevation data. The digital data are the source of position data for real-time support. The standard radar analog plotting procedures are slightly modified to produce continuous traces of component wind velocity versus altitude. The T-9 system has been proven reliable and is in increasing demand at WSMR. Specified accuracy is  $\pm 2$  miles per hour for a wind averaged over 250 feet.

#### 11. PRESENT AND FUTURE REQUIREMENTS

Future plans for the Forecast Unit include incorporation of more minicomputers for data processing, analysis, and display to help automate weather analysis and forecasting at WSMR. This ambitious program entitled SUPERMET is presently in the development stage and will utilize real-time input from automated CMD observations and be able to interrogate various sites on the missile range for real-time meteorological input. Various initial computer programs have been developed for SUPERMET which include:

- Hourly and daily temperature forecasts
- Winds aloft forecasts
- Thunderstorm potential and probability forecasts
- Likelihood of contrail formation forecasts
- Air pollution forecasts
- D-values, altimeter setting forecasts, along with pressure altitudes
- Mountain wave potential forecasts
- Nuclear explosion fallout prediction forecasts
- Chaff drop 3-4 dimensional trajectory forecasts

In addition, SUPERMET possesses the capability to be called up on the computer on a real-time basis to calculate sunrise, sunset times, solar angles, and sunrise times aloft for any location on Earth. Calculations of density,

density altitude, precipitable water, index of refraction, standard atmosphere variables to 20,000 meters, civil, nautical, and astronomical twilight times for the Earth, variations of the speed of light and sound under present atmospheric conditions, and various moisture parameters such as specific humidity, mixing ratio, etc.

Many additional forecast programs are planned for SUPERMET in the future. Plans are envisioned for the incorporation of an active CRT computer scope at the forecast desk so that the forecaster on duty can have at his fingertips all the assistance possible in his weather analysis and weather forecasting decisions along with computerized charts of weather data and computerized tables of various climatological data.

Future programs for the Forecast Unit include support of the B-1 bomber program, support to the WSMR high-energy laser project, and support to future solar energy research on WSMR.

Additional future plans of the WSMR Met Team include utilization of automated GMD data in support of weather forecasting and unguided rocket impact prediction. Also impact prediction will be served by a new generation of portable and solid-state T-9's to track PIBAL's for more accurate wind aloft information. Plans also include utilization of a WSMR network of automatic weather stations coupled with satellite data collection platforms to provide a mesometeorological network for real-time weather data and for future modeling and forecasting. The Forecast Unit also envisions incorporating data from new ionospheric sounders (the Dynasonde) and also from new SOTIM systems to be fully automated incorporating a microprocessing system.

## 12. CONCLUSION

The WSMR Met Team provides a multitude of meteorological services for the missile range and its users. This high-quality support that is provided today must continue to become more accurate and more detailed to meet future needs. To achieve this goal, ASL plans to automate more data collections and continue to develop more real-time applications in the areas of impact prediction and weather forecasting.

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## WHITE SANDS MISSILE RANGE USERS HANDBOOK

### CHAPTER 14

#### MISSILE FLIGHT SAFETY

##### 14-1 Requirements for Flight Termination Systems (FTS)

The requirements for FTS vary depending upon vehicle size, weight, and shape; vehicle performance characteristics; and flight patterns to be employed. This section establishes and outlines the requirements for various FTS and prescribes the procedures to be followed in designing and qualifying the FTS for use on WSMR. These criteria are applicable to all users conducting operations involving the launch and flight of missiles, drones or any other unmanned vehicles having the capability of leaving the test area boundaries of WSMR. (Some vehicles, which have no capability to get outside the test area, can be tested at WSMR without an FTS.)

The Chief, Operations Control Division will determine whether FTS is required for vehicles proposed for WSMR. Generally vehicles capable of exceeding the WSMR boundaries will require FTS. The following are exceptions:

a. Vehicles that cannot exceed WSMR boundaries but are associated with tests that indicate evacuations and roadblocks are not adequate to both protect range facilities and/or personnel and accomplish test objectives, may require FTS.

b. Certain high altitude probes that can exceed range boundaries are excluded from FTS requirements. The nature of these types of met rockets are such that even if they did carry flight termination systems, adequate devices do not exist for measuring the performance during the critical portions of flight. The NIKE boosted rockets are a prime example of this situation. Their second stage burning periods are too short to permit a sound evaluation of their performance. Negate systems have been tried in which the capability of denying ignition to the second stage existed, but the problem of measuring vehicle attitude, and taking into account the time variation in second-stage ignition devices was not practical because the cost of attitude measuring systems and accurately timed ignition devices preclude their use. It has been found that in order to have a good reliable impact prediction, its display must be as nearly continuous as possible. Even vehicles such as the Aerobee create Instantaneous Impact Prediction (IIP) problems in the neighborhood of booster burnout where thrust and, therefore, vehicle acceleration suffer a discontinuity. Ideally, single stage rockets are the best from this standpoint. Vehicles having extended coast periods between stages which do have good impact prediction display are those where the coast period occurs nearly exoatmospherically and are not related to high altitude probes. An example of this is the Pershing guided missile.

FTS used on missiles launched at, into, or from WCMR will be designed by or approved by WSMR. Normally, this approval is given by the Chief, Operations Control Division and obtained through the NR Project Engineer.

a. Ballistic and inertially guided vehicles requiring FTS must have a command-type FTS (WSMRR 385-17). This system is required to be effective only for the duration of powered flight on ballistic missiles.

b. Radio controlled missiles and targets requiring FTS must have a fail-safe type FTS (WSMRR 385-17). Fail-safe means a system whereby flight termination is initiated by loss of capability to control the vehicle. Fail-safe is initiated either by loss of RF command guidance for a specified duration of time (determined by WSMR) or by a decrease in the vehicle electrical power below a level necessary to maintain confidence in system performance. (A command FTS may be used in conjunction with the fail-safe system, provided the command FTS does not degrade the fail-safe system.)

The basic need for utilizing a fail-safe system derives from the fact that on vehicles on which it is used, the command link to the vehicle must be depended upon for proper guidance and control. When conditions arise which preclude positive control of the vehicle, such as malfunction of the command control system and essential electrical or mechanical power sources, the FTS must automatically recognize the failure and execute the desired flight termination action. The time allowed to activate the system under failure conditions of this type may be designed as fixed or variable depending upon variation of user test parameters and test objectives. However, the fixed or set activation times are determined after considering such factors as vehicle performance capability, flight path of the test and size of the available test area. But, in any case, the activation times are long enough that momentary interruptions and minor disturbances do not trigger the system.

The activation of the FTS must limit range.

a. For unguided ballistic missiles and for ballistic missiles guided during burning, thrust termination must be accomplished with a stable body resulting when possible; otherwise, a tumbling body with a known ballistic coefficient must result. For missiles having the ability to change course during the entire flight, flight termination will terminate thrust and sever the air frame into a minimum number of sections required to produce tumbling.

b. Certain smaller target missiles will be required to provide a means of thrust termination and a parachute recovery system.

c. Larger target missiles, especially those obtained by droving full-scale aircraft, will be required to provide a means of thrust termination and severance of the airframe into a minimum number of sections required to produce tumbling.

d. Flight Termination Systems (FTS) for multi-staged missiles must be designed such that flight termination is assured in any and all stages deemed necessary by the Chief, Operations Control Division.

The user must provide the documentation of the FTS required below and, in addition, must provide any documentation that may be determined by WSMR to be unique to the missile. This documentation is required to establish the FTS requirements, conceptual design, detailed design, and test criteria and evaluate the qualification test results for all missiles launched at WSMR, whether or not the missile and/or FTS are under development, or have been launched at other missile ranges. Concept approval of the FTS should be sought at the earliest possible date after the requirement for testing is known. For new designs, the process of system approval generally requires a lead time of 12 months.

After qualification testing has been accomplished and approved, the final engineering design proposal of the FTS should be submitted at least 90 days prior to the first scheduled launch and must include mechanical layouts, electrical schematics, narrative description of the functions, performance, and checkout procedures, plus charts and graphs as necessary for clarity and illustration of critical parameters. The engineering design proposal must also include certification by the user that all components of the FTS will function under all environmental conditions to which they will be subjected (i.e., extremes of altitude, temperature, pressure, acceleration, etc.). The minimum environmental qualification criteria that the user must meet are as follows:

a. Shock - Apply qualification shocks whose shock spectra levels are twice the amount required to duplicate or envelop the shock curve of each service mode worst-case condition shock, measured or unexpected during actual service, at least once along both directions of three principal axes (a minimum of 6 months).

b. Vibration - Apply qualification vibrations having a Power Spectral Density (PSD) envelop which is 10 dB above each service mode worst-condition, measured or expected during actual service, along each of the three principal axes for a duration 1.3 times the (measured or expected) service duration associated with each service mode, or a vibration time for 30 seconds per axis minimum, whichever is greater. If flight vibration levels are very low, a negotiated vibration level and duration will be applied in order to prove the workmanship and reliability of the flight termination system equipment.

c. Sustained Acceleration - Apply qualification accelerations of sustained value equal to 1.3 times the worst-condition, measured or expected during actual service, along each of the three principal axes for a duration not less than 1 minute.

d. Temperature - Apply qualification temperatures of 20°F above and 20°F below the extremes measured or expected for a period equal to the

service exposure time to include storage time, preflight time and flight time. The 20°F margin applies to flight temperature requirements in the range from -40°F to +185°F. Flight temperature outside of this range will require different margins as dictated by monitoring accuracy, test methods and confidence in baseline data.

e. Special Considerations: Analysis of the particular system or structure to be qualified may reveal the need for deviating from the foregoing criteria to include more stringent minimums, application of simultaneous qualification environments, as well as any other environmental qualification environments not specified above, which may be required to ensure the adequate reliability of the particular FTS. For this reason, users are urged to coordinate with WSMR on FTS concepts and design at an early date to avoid delays due to unforeseen problems which are outside the scope of general policies.

Following approval and installation of the system in the missile, an operational acceptance test will be made at WSMR prior to each launch. This test is a very thorough one intended to prove the integrity of the entire system, including missile antennas, receiver-decoders, flight power supplies and missile circuitry to the point just short of activating the explosive device. These tests will be performed by WSMR Operations Control Division personnel on all missile systems which are flown in the command-mode. For fail-safe systems, the user must perform these tests during the prelaunch systems check and certify to the Operations Control Officer-in-Charge that these tests were conducted and were satisfactory. Operational approval and acceptance of the system for each launch will depend on test results.

Modification to an approved airborne FTS will not be made without prior concurrence of WSMR. Approval of any proposed modification will be obtained in the same manner as the approval of the original system.

Data for FTS will be submitted in accordance with the following:

a. Command FTS data requirements

(1) The user will provide drawings of the missile configuration including layout of all stages, staging provisions and sections as listed below:

(a) Motors

1. Solid Propellant - Case material and thickness, propellant type, loading description, description of bonding material and thickness, nozzle(s) throat diameter.

2. Liquid Fuel - Type fuel/oxidizer, etc., description of valves, diaphragms, size/thickness/material of fuel/oxidizer lines.

- (b) Missile Guidance/Control Provisions - Include a description of the system for sensing and implementation.
  - (c) Staging/Separation/Ignition Provisions - Include methods of effecting time delays, provisions for lock-out, etc.
  - (d) Mounting Areas - Include access provisions for installing FTS equipment and installation of FTS antennas.
  - (e) The sequence of missile assembly, test operations, and the time frame.
- (2) Drawings describing all FTS mounting provisions, battery boxes, wiring harnesses including connectors, wire sizes, insulation and shielding, antenna power dividers, coaxial cables, and connectors, and the missile umbilical provisions for FTS.
- (3) Drawings of specifications, data circuitry and mechanical details of all components of the FTS. Circuit analysis establishing total current requirements.
- (4) Data relative to missile/rocket environment during prelaunch, launch and flight relative to all components of the FTS to include the following:
- (a) Temperature - Storage, preflight and flight
  - (b) Shock - Ignition, launch, stage separation, deployment/maneuver function, etc.
  - (c) Vibration - Handling, transport/air carry, deployment/maneuver
  - (d) Acceleration due to propulsion of each stage
  - (e) Acoustical noise (if applicable)
  - (f) Blast overpressures on FTS equipment, such as from stage separation (as applicable)
  - (g) Attenuation of RF to the FTS due to motor burning plumes
  - (h) RF attenuation of the FTS due to ionization, heating, etc., on reentry (if applicable)
  - (i) Humidity levels expected during operations
  - (j) Dust, sand exposure to FTS during operations
  - (k) Environmental levels required to cause missile break-up

(5) Qualification Test Procedures - Data and reports establishing that all components perform reliably to specifications in the applicable environments defined in (4) above when subjected to tests with the safety margins required by WSMR. WSMR will establish/approve the qualification test procedures including test parameters, test levels, time durations monitoring/recording provisions, the number of samples and the method of selection of samples. Samples subjected to qualification tests will be considered expended by WSMR and may not be flown in an FTS at WSMR. Generally, all test levels will meet the requirements stated in items a through c, page 12-2. WSMR must approve final criteria and also retains the option to witness qualification tests of FTS components.

(6) Lot qualification tests and acceptance tests approved by WSMR are required for all ordnance components in the FTS. All ordnance initiated mechanical devices will be tested under conditions of applicable dynamic loading. Detonators, gas generator, explosive trains, explosive charges, explosive valves, switches, etc., will require appropriate tests and analyses to establish reliability in the missile environments. Special ordnance tests include:

- (a) Detonators - Bruceton analysis or approved substitute to establish all fire and no-fire current requirements.
- (b) Bruceton or Langley analysis or approved substitute of all interfaces in the explosive train to establish reliability of propagation across all gaps at applicable environmental extremes.
- (c) Explosive Valves - Must be tested under dynamic conditions of liquid flow, working pressure and vibration.
- (d) Safe and Arm Devices - Must demonstrate performance as specified before, during, and after all applicable environmental tests.
- (e) WSMR will establish/approve the tests required to establish, qualify and approve the explosive charges including demonstrations of complete explosive systems.

(7) WSMR will establish/coordinate/approve FTS installation, test and operation procedures before such operations proceed. Standing Operating Procedures (SOP's) for all operations involving FTS explosives are required and must be approved by WSMR. Two copies of the proposed SOP will expedite handling, as they must be reviewed by both Operations Control Division and the Safety Office.

b. Fail-safe FTS requirements

(1) The user must provide scaled diagrams of the general arrangement, dimensions of the missile, component positions in the missile, and information as listed below:

- (a) Booster Type - (if applicable)

- (b) Motor Type - Include fuel and fuel system and potential hazards associated with dispersal of fuel.
  - (c) Missile Guidance/Control Provisions - Include a description of the system for sensing and implementation.
  - (d) Staging/Separation/Ignition Provisions - Include methods of effecting time delays, provisions for lock-out, etc.
- (2) A complete set of detailed schematic diagrams of the proposed FTS to include any component(s) or vehicle subsystems common to the FTS circuitry.
- (3) A complete, detailed narrative description of the FTS
- (4) A complete parts list of all FTS components
- (5) An FTS battery (back-up, if applicable) load analysis to include flight loads based on nominal conditions and fail-safe conditions. Manufacturers' specifications (i.e., rating, capacity) are also required.
- (6) A detailed set of schematics, as well as a narrative description of all FTS pyrotechnics to include ordnance specifications. This should include composition of ordnance material and connections.
- (7) Systems utilizing a parachute FTS should be accompanied with parachute load limits, parachute drift data as a function of various vehicle speeds and wind velocity, and a sequence of parachute system initiation.
- (8) Antenna characteristics and pattern measurements
- (9) A procedure for prelaunch FTS operational checkout to include positive checkout of RF link.
- (10) For additional requirements, refer to paragraphs a.(5) and a.(6) above.

#### 14-2 Data Requirements for Unmanned Air Vehicles

##### General Vehicle System Data

The following is a list of data which will not, in general, change appreciably from flight to flight. These data should be updated as changes of vehicle configuration or revised information become available.

- a. A comprehensive description of the vehicle system must be provided to include the following:

- (1) Vehicle characteristics and performance capabilities

(2) Ground support equipment description to include signal processing affecting the FTS

(3) Guidance equipment description to include all modes from prelaunch to aerial or ground target intercept

(4) Airborne missile equipment description to include FTS signal flow diagram

(5) Various telemetry functions are often used by Operation Control during missile flight to detect possible missile malfunctions, to prevent overshoot of the IIP, to determine vehicle performance, and to monitor the status of the destruct system where applicable. The type of functions normally required and monitored for the above purposes are:

- (a) Control-surface position data
- (b) Longitudinal acceleration
- (c) Motor chamber pressure
- (d) Vehicle attitude data
- (e) Destruct system monitors
- (f) Bank angle
- (g) Altitude

A telemetry measurement list of available functions for possible use by flight safety for the above stated purposes should be provided.

(6) Tracking aids compatible with range instrumentation as well as system peculiar tracking aids. WSMR requires two tracking sources for flight safety. Whenever possible system peculiar tracking information may substitute as one of the required tracking sources.

b. Flight Safety Analysis

(1) Nominal trajectory to the desired aerial or ground target

(2) Three-sigma deviation of trajectory and impact points

(3) Footprint information resulting from the FTS action. This information must include all hazardous vehicle sections. The footprint should be defined in terms of probability values and their respective envelopes, i.e., 1-sigma, 2-sigma, and 3-sigma bivariate distributions.

(4) Flight failure modes to include effects of a high probability failure mode and resultant impacts.

(5) Maximum energy trajectory

(6) In addition to the above, all projects contemplating the use of explosive warheads will submit the following information:

- (a) Location in space where detonation is intended
- (b) Effect of detonation on the missile (dispersion of the missile pieces)
- (c) Dispersion of fragments of the warhead
- (d) Circuitry showing how the warhead is armed, exploded, and locked out. Systems time delays are to be noted.

(7) For vehicles which use a parachute recovery system for safety purposes, the descent rate versus altitude profile is necessary.

(8) The above data must be accompanied by substantiating documentation

c. Vehicle Trajectory Information

(1) These data are trajectory dependent and must be supplied for each flight or group of similar flights. All trajectory data is required from launch through impact of each stage or major component, i.e., nose cone, adaptor section, etc. A separate printout should be provided for the normal trajectory and for each stage from ignition through impact.

(2) Nominal trajectory data is always required; in borderline cases, a dispersed trajectory may be required.

(3) The following additional requirements are also required for each missile flight or group of similar flights.

A write-up on the reentry burnup conditions of the stages/payload, if expected, must be submitted. When applicable, the following are desired:

(a) The time and condition during flight for which it can be guaranteed that the remaining missile stages will be entirely consumed by heat upon reentry into the atmosphere to include a complete discussion of assumptions made, equations used, and method of analysis.

(b) Three sigma areas are requested for unignited or no-separation conditions of the vehicle staging.

(c) A history of previous launches of the particular vehicle is highly recommended. This would give the range a better conception of the expected performance of the vehicle.

(4) A trajectory simulation on digital tape will be required when analysis of missile performance capabilities reveals that an instantaneous

Impact predictor (IIP) must be used for real-time Missile Flight Safety decision making. An IIP is normally used to monitor those missiles whose potential at any given time along a nominal or abnormal trajectory is such that present position data becomes meaningless due to the large difference between actual missile position and projected missile impact in case of a destruct action. If this difference is greater than 3 miles at any point along the trajectory, an IIP will be required in order that trajectory simulations can be generated by WSMR for Flight Safety Officer analysis and pre-mission dress rehearsal. The Project will supply the trajectory simulation on digital tape in launch coordinates. This tape is converted in deferred-time to produce an input tape for a real-time program called SIMPAS. SIMPAS transforms the simulation to pointing data (PAS) in radar coordinates, and this PAS is recorded on analog tape. Playbacks from that analog tape then provide radar inputs for real-time software checkout and premission demonstrations. Generally, only those projects utilizing an active FTC will require a trajectory simulation. The Chief of Operations Control will decide any exceptions. Requirements for a digital simulation tape provided to WSMR are as follows and must be submitted at least 5 working days prior to a scheduled operation utilizing the simulation data.

- (a) Seven-track digital tape at a density of 800 bits per inch (BPI) with data presented as 6-bit IBM BCD or UNIVAC field data code.
- (b) One trajectory per tape with end-of-file mark at the end of the trajectory.
- (c) Each tape record is in the following format: T, X, Y, Z, where T is Time-Since-Launch, in seconds and tenths of seconds; X, Y, and Z are position in feet, using a right-handed cartesian coordinate system with positive X-east, positive Y-north, and positive Z-up. X, Y, and Z should be single precision floating point numbers such that T, X, Y, and Z can be written and read by FORTRAN program or a FORTRAN-tape-compatible program using the format: F5.0, 3F12.0. Physical records should be same as logical records and the number of characters in a record should be a multiple of six.
- (d) The desired message rate is ten samples per second in even increments of time - 0.000, 0.100, 0.200, 0.300, 0.400, etc. The user must provide WSMR the coordinates of the launch point or origin of the data. Origin or launch point data should be geodetic latitude and longitude in degrees, minutes, and seconds and mean-sea-level (MSL) altitude in feet.
- (e) Drag coefficient versus Mach number
- (f) Reference area of vehicle
- (g) Weight to drag ratio ( $\beta$ ) of intact air vehicle and major pieces that result from a destruct action where applicable.

(5) Physical vehicle data is required in order that proper preflight impact prediction services for unguided missiles can be generated for WSMR flight safety use. To provide these prediction services, the Forecast Section, Atmospheric Sciences Laboratories (ASL) requires the following data by 10 working days prior to launch:

- (a) Launcher exit conditions
  - 1. Effective launcher length
  - 2. Launcher exit velocity
  - 3. Launcher exit time
- (b) Aerodynamic Data
  - 1. Drag coefficient versus Mach number
  - 2. Normal force coefficient versus Mach number
  - 3. Center of pressure versus Mach number
  - 4. Aerodynamic damping coefficient versus Mach number
  - 5. Reference area
  - 6. Reference length
- (c) Inertial Data
  - 1. Thrust versus time (burning phases)
  - 2. Center of gravity versus time
  - 3. Pitch and yaw inertia versus time
  - 4. Mass versus time
  - 5. Nozzle exit area (burning phases)
  - 6. Rocket Length
- (d) Parachute data (if applicable)
  - 1.  $W$  = Weight of suspended parachute and payload (lbs)
  - 2.  $S$  = Effective area of parachute ( $\text{ft}^2$ )
  - 3.  $C_d$  = drag coefficient for parachute (dimensionless)

(e) Sphere Drop Data (if applicable)

1. Drop Altitude (ft MSL)
2. Weight of sphere (lb)
3. Diameter of sphere (in)
4. True airspeed of the aircraft (kn or ft/s)
5. Heading of aircraft (deg true north)

(f) Any changes of the above parameters should be provided as soon as they become available, so that the proper adjustments can be made.

(6) To determine permissible test envelopes for guided vehicles, WSMR Operations Control must evaluate vehicle performance and characteristics under a variety of potential flight conditions. In order to accomplish this, the following vehicle physical data is required:

(a) Aerodynamic Data

1. Drag coefficient versus angle of attack and Mach number
2. Normal lift coefficient versus angle of attack and Mach number
3. Center of pressure versus Mach number and angle of attack
4. Reference normal cross-section
5. Reference axial cross-section
6. Maximum stable angle of attack versus altitude and Mach number

(b) Inertial Data

1. Thrust versus time
2. Center of mass versus time
3. Mass versus time
4. Vehicle dimensions
5. Vehicle mass distribution
6. Vehicle normal acceleration structural limit

(7) Requirements for air launched vehicles. The following specific data are also required if an air launch is desired of either an unguided or guided ballistic missile.

- (a) Type of launch aircraft
  - (b) Launch quadrant elevation (QE) and altitude of launch aircraft at launch
  - (c) Launch velocity in feet per second or mach number
  - (d) Launch altitude in feet
  - (e) The desired launch point and flight azimuth. (The launch point coordinates should be given in geodetic latitude, longitude and height.)
  - (f) Hold-fire limit downrange from the nominal launch point
  - (g) For launches other than level flight, a description is required on how the launch QE and launch azimuth will be determined for vehicle release.
  - (h) Flight profile for each stage is required. As a minimum, the nominal flight profile is required from launch to impact showing altitude in feet versus downrange in feet with timing marks in seconds indicated on profile. Included must be profiles for all of the unignited or no-separation conditions of the vehicle.
- (8) Special Type Vehicles. Bombs, special parachute drops, etc., will be considered special cases and the following items are required:
- (a) Profile trajectory of the drop, altitude in feet versus downgrade distance in feet. Include trajectories with parachute opening and with parachute not opening.
  - (b) Timing marks in seconds indicated on the trajectory
  - (c) Altitude of vehicle release
  - (d) Velocity at time of release
  - (e) Weight of each object to be dropped
  - (f) Expected 3-sigma dispersion area
  - (g) Total time of flight of each object dropped

14-3 Waivers

a. General

- (1) Compliance with the criteria contained herein is required during all missile operations conducted at WSMR unless specifically amended or waived by the Commander, White Sands Missile Range. However, it is recognized that a deviation from the prescribed criteria may be necessary for

some missile operations if program test objectives are to be achieved. Whenever a deviation from the established criteria appears to be necessary, a formal request for waiver should be submitted. Waivers of the missile flight safety criteria and requirements contained herein are granted only by the Commander, White Sands Missile Range, and only if the program test objectives are considered to be of sufficient importance, if these objectives cannot otherwise be met, and if in his judgment the risk involved is reasonable.

(2) Approval of waiver requests often require detailed investigations. It is, therefore, prudent to submit a request for waiver as early as possible to prevent scheduling delays. If a decision on a waiver request is required by a specific time, the request must be submitted at least 60 days before such a date. All waiver requests and supporting data will be submitted as follows:

Commander  
US Army White Sands Missile Range  
ATTN: STEWS-NR-C  
White Sands Missile Range, NM 88002

b. Data Requirements

(1) In deciding whether to grant a waiver, it is important to know what additional hazard or risk will thereby be incurred. For missile flight safety, this hazard is to be evaluated by means of a detailed probability study which includes:

- (a) The derivation of an impact probability density function
- (b) The assessment of lethal areas
- (c) The computation of hit and kill probabilities, based upon land areas and population densities
- (d) Computation of impact effect of missile clean body and destruct debris on those WSMR Test Site shelters which could be hazarded by the missile test operation. Normally, the debris from aerodynamic missiles which hazard populated areas must be such that the existing shelters provide adequate safety. The specific requirements, assumptions and format of the required probability study will depend upon the test under consideration and will therefore be furnished by the user for each such test.

(2) Supporting data for the waiver request must further include:

- (a) A statement of the technical or other requirement which makes the waiver necessary
- (b) A discussion of the effect on the program if the waiver is not granted

(c) A detailed description of the proposed test(s) or operation(s)

c. Conclusion. Satisfaction of the flight safety requirements contained in this document does not constitute flight safety approval of a proposed test. Approval will be granted only after evaluation of all data results and determination by WSMR that the test can be conducted safely. Once a flight safety system has been approved by WSMR, no modification may be made without prior approval of the Chief, Operations Control Division.

**Appendix D**

**KWAJALEIN MISSILE RANGE  
ROCKET SAFETY**

**(EXCERPTS FROM LAUNCHER SETTING AND IMPACT  
PREDICTION CALCULATIONS AND  
FLIGHT SAFETY PLAN 3-81)**

LAUNCHER SETTING AND IMPACT PREDICTION CALCULATIONS  
FOR  
UNGUIDED ROCKETS AT KWAJALEIN MISSILE RANGE (KMR)

INTRODUCTION

Wind has a significant effect on the trajectories and impact locations of unguided rockets. Computer programs are used at KMR to process wind data and to determine launcher settings which largely remove the effect of measured winds from these impacts. During a countdown Range Operations personnel compute launcher settings for the range user. These settings are evaluated independently by Range Safety. Impact predictions are made for each stage, which are used with dispersions to assure that the launch can be conducted safely.

WIND PROFILE MEASUREMENT

Rawinsondes, or radio instrumented balloons, are used to determine winds between 20,000 and 100,000 feet. Data from a rawinsonde track include time, elevation, azimuth and barometric pressure from which altitude is computed.

Winds below 20,000 feet are measured by the Automated Wind Finding System. Sensors for this system include five anemometers on a 200-foot tower and two X-band radars for balloon tracking. Each frame of data from the system includes range, azimuth, elevation and tracking status for both radars; wind speed and direction at each anemometer level and time. These data are transmitted at 10 hertz to Program WFIND, a real-time job executing in the CDC 7600 at the Instrumentation Control Center. For a major launch, the program is normally executed continuously from approximately T-90 minutes. It edits and filters incoming data and it computes wind velocity for an input set of altitude layers. It maintains in memory a wind profile using these layer break points. At any time that sufficient valid data are processed to determine the wind in any layer, the old wind is replaced by the new one in that layer. Each layer is time-tagged so that data age may be seen.

When launcher settings are desired, the Range Operations launcher setting program is executed and the launcher settings and current wind profile are written on disks for Range Safety access. By continuous, alternate tracking of balloons by the two radars, low and intermediate level winds are monitored accurately for approximately the last hour before launch.

IMPACT PREDICTION AND LAUNCHER SETTINGS

The use of ballistic tables to compute impact points, while clearly less accurate than a six-degree-of-freedom simulation, is standard practice for many applications and is used at KMR. The primary advantages of using ballistic tables are simple implementation and fast execution. The method has provided acceptable accuracy for unguided rocket launches at KMR. Prior to launch of new systems, impact points

are computed with six-degree-of-freedom (6D) trajectory simulations using test wind profiles. The profiles were selected for relatively high windspeeds and strong shear patterns. The 6D impact points are compared with those using ballistic tables. These tests have been helpful in showing when additional data or a change in modeling is required for low-acceleration, very wind-sensitive rockets.

The range user provides a ballistics and safety data package to KMR prior to conducting a launch program. This package includes in part desired payload impact point and a set of ballistics data for each stage and for unignited stages when appropriate. The ballistics data include: (1) impact range versus launcher elevation tables, (2) wind weighting tables, (3) unit wind effect tables and (4) earth rotation (coriolis) effects. The first three above are computed by using trajectory simulations with a spherical nonrotating Earth model. A Kwajalein atmosphere should be used in all trajectory simulations in generating these data.

Payload and stage impact predictions are made by performing a vector sum of the zero wind, no-coriolis impact vector, the wind impact displacement and Earth rotation (coriolis) effect. The zero-wind, no-coriolis impact vector is computed by using launcher azimuth with a range determined by interpolation from the impact range versus launcher elevation table. The Earth rotation displacement vector is the difference between impact points from nonrotating and rotating earth trajectory simulations using zero-wind and nominal launcher settings.

A wind weighting table specifies the fraction of impact displacement due to wind which is contributed from winds between the surface and corresponding altitudes. The wind weighting factor for a particular altitude band is computed by subtracting the interpolated wind weighting value at the lower altitude from the interpolated value at the higher altitude. Ballistic winds are computed by multiplying the average measured wind in each altitude band by the wind weighting factor for that band and summing the results.

Unit wind effect is the impact displacement due to unit value (1 foot per second) ballistic wind. Usually, it is provided for each stage as a function of launcher elevation in head, tail and cross wind directions. To achieve acceptable impact prediction accuracy for very wind-sensitive systems, it may be necessary to include its variation with windspeed. The ballistic wind is resolved into head/tail and cross components. The wind impact displacement vector is the product of the components of ballistic wind with the appropriate unit wind effect components. The wind impact displacement vector is then rotated to a N-E coordinate frame. It is vector-summed with the zero-wind, no-coriolis impact vector and the coriolis vector to determine the predicted impact point.

Launcher settings are determined by iteratively computing payload impact predictions until acceptable accuracy is reached.

## 1. INTRODUCTION

In order to launch an unguided rocket under circumstances in which the stage impact locations must be constrained, it is necessary to determine the launcher settings such that predictable impact displacements will be taken into consideration. The predictable displacements considered by this program are those due to the coriolis effect and those due to ambient winds. Unpredictable displacements, those due to dispersions, may cause the stage impacts to lie within a statistically defined region about the nominal impact points. Separate allowance must be made for impact dispersions when defining the area to which impacts are constrained.

Ideally, an integrating, six-degree-of-freedom computer program would be most accurate for computing launcher settings and stage impact locations. Unfortunately, a program of this sophistication could run as much as 20 to 1 slow, even on the fastest available computers. This lack of speed is not acceptable, during a launch countdown, because of the importance of using current wind data. The lack of exact knowledge of rocket ballistics and the inaccuracies caused by changing winds fully justify the computation of launcher settings and impacts by faster approximate means, using rocket parameters previously determined by more sophisticated programs.

This program has been designed for use with any ballistic rocket having one to four stages.

## 2. GENERAL DESCRIPTION OF PROGRAM

A primary consideration in the layout of this program was ease of understanding and of operation by the user. It was, therefore, constructed using many subroutines, instead of one large block, each of which may be simply modified, and improved when necessary, without affecting any other subroutine. If other subroutines are found to be needed, they can be added with a minimum of complication.

Essentially, the program reduces to the solution of a vector polygon, the components of which are: (1) the wind displacement vector, (2) the coriolis displacement vector, (3) the no-wind, no-coriolis range vector, and (4) the sum of these, the actual impact vector.

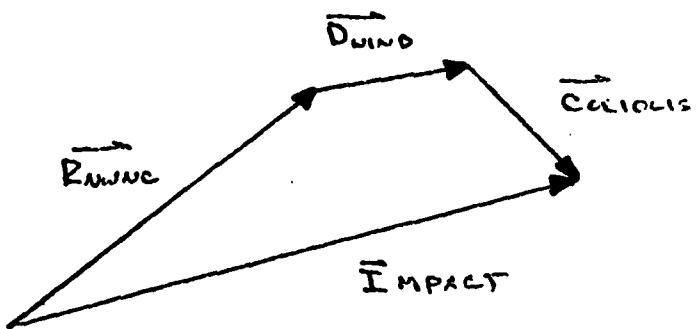


Figure 1

The Coriolis displacement and the no-wind, no-coriolis range vectors for each vehicle stage are Vehicle Peculiar data and are

inputs to the program. The  $\vec{R}_{nwnc}$  vector for each stage is a constant. The  $\vec{R}_{nwnc}$  vector for each stage is a function of launcher elevation. The  $\vec{D}_{wind}$  vector is a function of launcher elevation and of the current wind profile; it is computed by multiplying the "ballistic wind" for the stage by the "unit wind effect for that stage."

## 7. DEVELOPMENT PROCEDURE FOR VEHICLE PECULIAR DATA

Certain input information is required to adapt the program to the particular vehicle of interest. This information is to be provided by the range user, but a brief description of the manner of development is provided below, for general interest. Ideally, a six-degree-of-freedom simulator of the vehicle is used to develop these parameters.

### A. Wind Weighting Factors

First, the no-wind impact range for each stage is found using the no-wind nominal launcher elevation. Call these  $R_{nw}(S)$  where S indicates the stage. It is then desired to find the effect of a wind acting on each stage. A wind of constant magnitude, W, (normally 10 knots) is applied, in the range plane from 0 to 10 feet, 0 to 50 feet, 0 to 100 feet, and so on, until this wind has been applied all the way to some maximum altitude, call this MAXH, above which the wind has no appreciable effect. In each case, for each stage, the wind displacement (total displacement minus  $R_{nw}(S)$ ) for the W=10 knot wind to that altitude is recorded. Call this  $R_{ten}(S,H)$  where S again indicates the stage and H indicates the corresponding altitude up to which the wind has been applied. From this then,  $R_{ten}(S, MAXH)$  is the total wind displacement distance when the entire endoatmospheric portion of the trajectory is flown through a 10 knot range-plane wind. If one now performs the divisions:

$$R_{ten} (S, 10 \text{ feet}) / R_{ten} (S, MAXH) = WF (S, H)$$

$$R_{ten} (S, 50 \text{ feet}) / R_{ten} (S, MAXH) = WF (S, H)$$

.

.

.

$$R_{ten} (S, MAXH) / R_{ten} (S, MAXH) = WF (S, MAXH) = 1.0$$

Then  $WF (S, H)$  is the ratio of displacements caused by a uniform wind to altitude  $H$  to that caused by a uniform wind to  $MAXH$ . The tables of  $WF (S, H)$  vs.  $H$  are the wind weighting factor tables for the individual vehicle stages. These are entered into the program as vehicle peculiar data and will be called from the subroutine WINDWF. In actuality, the  $WF (S, H)$  tables will differ depending upon the direction and magnitude of the constant wind,  $W$ , and upon the launcher elevation used. However, these differences are relatively small. It is considered sufficiently accurate to develop the  $WF (S, H)$  tables using that quadrant elevation ( $QE$ ) which gives the desired impact location under no-wind conditions.

It should be recognized that the ratio  $WF (S, H)$  need not be always less than 1.0.  $R_{ten} (S, MAXH)$  is the total displacement for a uniform wind field to the top of the effective atmosphere. But if the wind is terminated at some lower altitude, the displacement may be greater. This is due to the two opposing sources of wind displacement: weather cocking and drift. Weather cocking of a particular stage occurs only during the powered portion of flight, and this displacement is into the wind. Drift occurs during the entire endoatmospheric flight; this displacement is with the wind. The slope of the  $WF (S, H)$  vs.  $H$  curve is positive when weather cocking is predominant, negative when drift predominates.

### B. Unit Wind Effect

Another missile parameter, called Unit Wind Effect (UWE), is obtained by the following:

$$UWE = \frac{R_{ten} (S, MAXH)}{W}$$

where W in this case is 10 knots. This is effectively the partial derivative of range with respect to range wind. UWE is also a function of launcher QE, more so than WF (S,H), therefore, additional runs to determine  $R_{ten} (S, MAXH)$  are made at different launcher elevations to provide a table of UWE (QE) vs. QE.

The above was computed using a range-wind. Since UWE is also a function of wind direction, the procedure is done over with a cross-range wind of magnitude W knots. This results in two tables per vehicle stage:

UWER (QE, S) vs. QE

UWECR (QE, S) vs. QE

$$\begin{aligned} & \frac{\partial R}{\partial W} ((QE, Stage)) \\ & \frac{\partial R}{\partial W} - f(QE, Stage) \end{aligned}$$

These are entered into the program as vehicle peculiar data and will be called from subroutine UNITWD.

### C. No-Wind, No-Coriolis Range

No-wind, no-coriolis range vs. QE is found simply by running the vehicle simulator for several launcher elevations which encompass the expected maximum and minimum QE. This table  $R_{nwnc}$  (S, QE) vs. QE will be used by subroutines RAVSQE and QENAZ.

### D. Coriolis Displacement

The coriolis displacement vectors, one for each stage of the vehicle, are determined by the trajectory itself. However,

within the accuracy of the program, the coriolis vectors can be determined before hand, based upon the nominal trajectory to be flown, and can, therefore, be input to the program as constants. This can be easily accomplished by running the simulator once with and once without Earth rotation. Normally, the booster coriolis displacement is negligible.

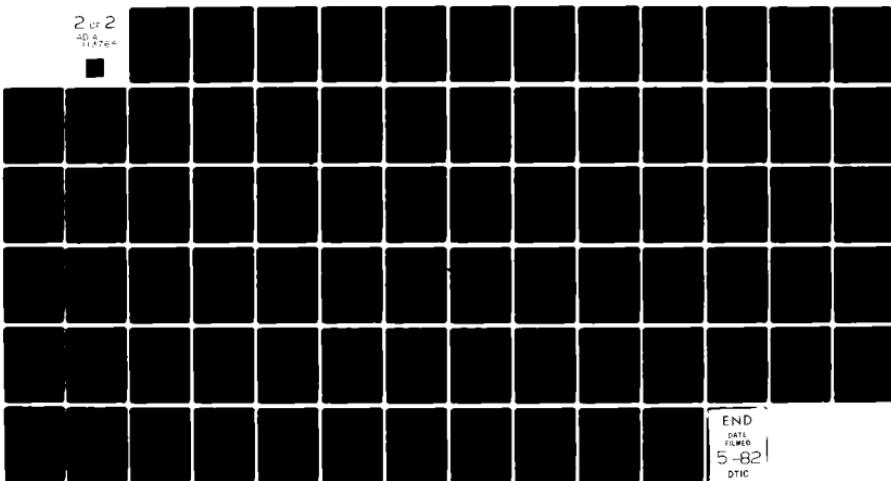
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RANGE COMMANDERS COUNCIL WHITE SANDS MISSILE RANGE NM—ETC F/8 13/12  
UNGUIDED ROCKET SAFETY: AN INFORMAL COMPENDIUM OF RANGE TECHNIC—ETC(U)  
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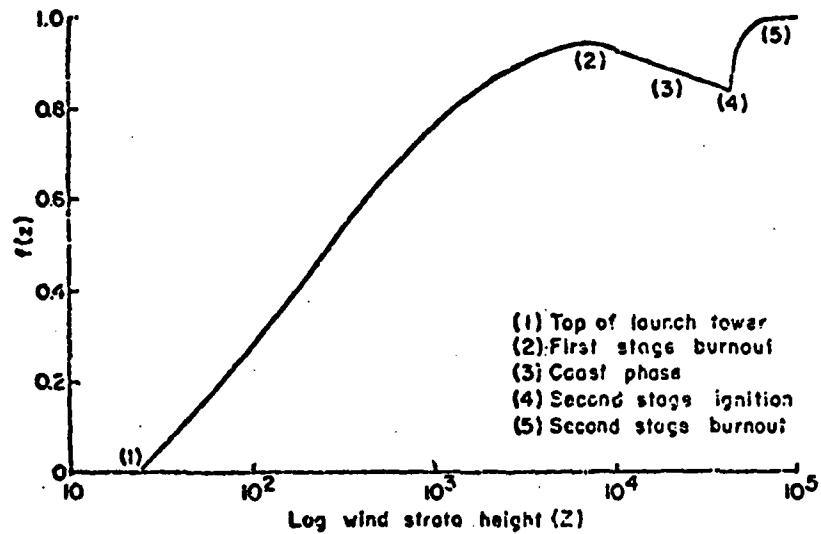
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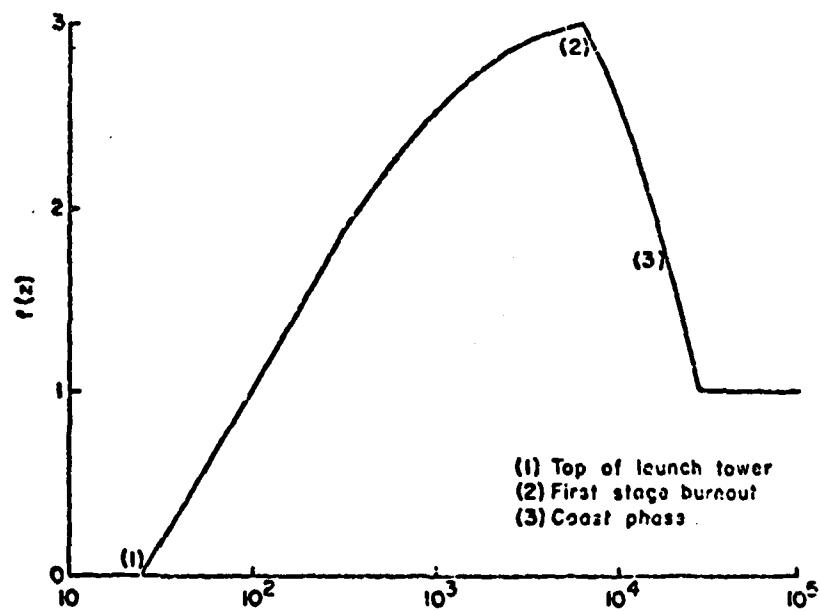


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Figure 2  
Typical Wind Weighting Factor Curves (from Ref. 1.)

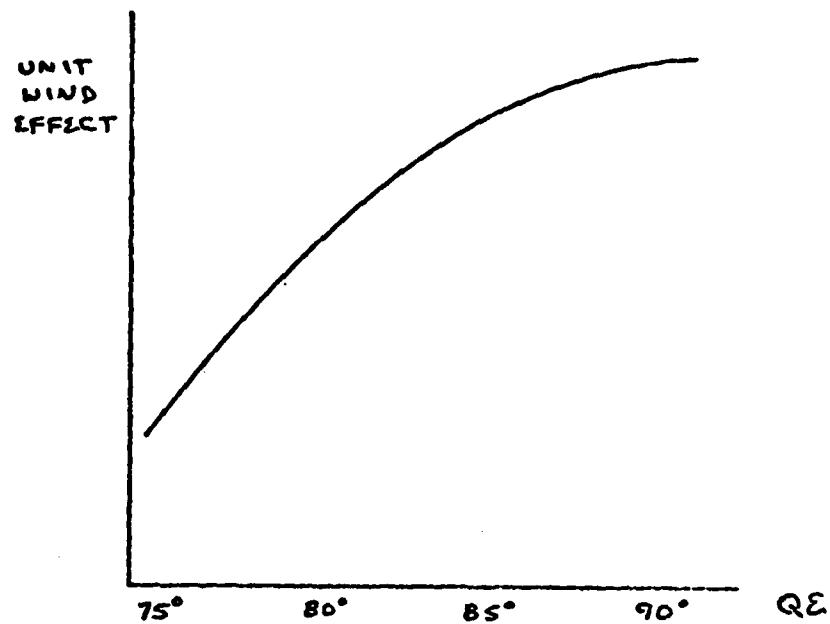


Curve for Payload (second stage) of a Two Stage Vehicle

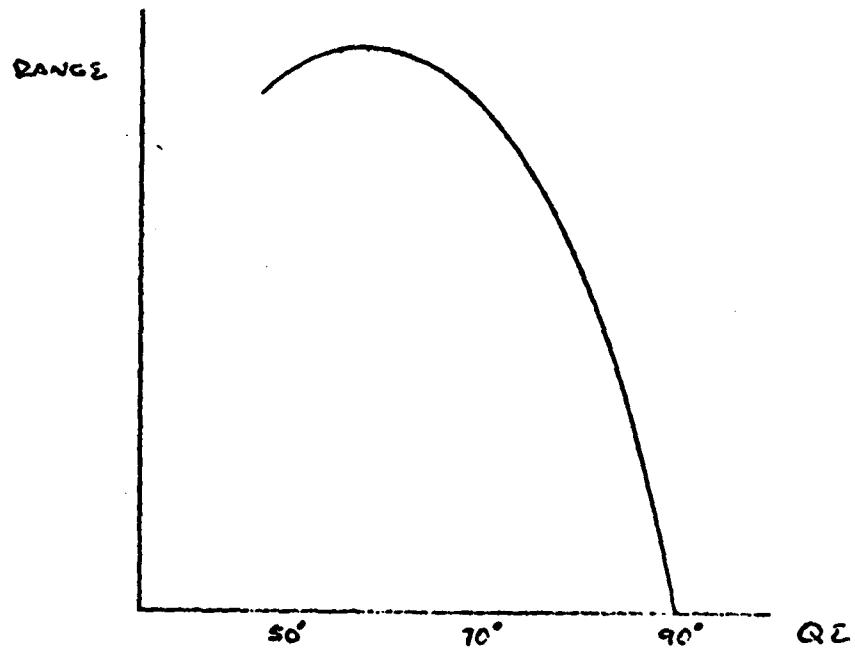


Curve for a Single Stage Vehicle or for the Booster of a Multi-Stage Vehicle.

Figure 2a.



Typical Stage Unit Wind Effect vs. Launcher Elevation



Typical Stage Range vs. Launcher Elevation

DEPARTMENT OF THE ARMY  
HEADQUARTERS KWAJALEIN MISSILE RANGE  
APO San Francisco 96555

FLIGHT SAFETY PLAN

3-81

METEOROLOGICAL ROCKET/KWAJALEIN

This Flight Safety Plan specifies the criteria and procedures which apply to launches of the SUPER-LOKI meteorological rocket with the PWN-11A Instrumented Dart payload from Kwajalein Island.

FOR THE COMMANDER:

TRACY N. PURITZ  
Captain, AGC  
Adjutant

## ABBREVIATIONS AND ACRONYMS

AFRS	American Forces Radio Service
ELA	Effective Launch Azimuth
EQE	Effective Quadrant Elevation
FAA	Federal Aviation Administration
KMR	Kwajalein Missile Range
KOP	Kentron Operating Procedure
LA	Launch Azimuth
NLT	No Later Than
NOTAM	Notice to Airmen
PIBAL	Pilot Balloon
QE	Quadrant Elevation
RKS	KMR Range Safety Office
RKT	KMR Range Operations Office
RSO	Range Safety Officer
TWX	Teletype Transmitted Message

## TABLE OF CONTENTS

<u>Paragraph</u>	<u>Subject</u>	<u>Page</u>
	Abbreviations and Acronyms	D-13
1	Purpose	D-15
2	Scope	D-15
3	Policy	D-15
4	Introduction	D-15
5	Definitions	D-15
6	Flight Safety Requirements	D-16
7	Safety Launch Approval	D-17
8	Responsibilities for Safety Actions	D-17
9	Flight Safety RED Criteria	D-18
10	References	D-18
Figure 1	Caution Area	D-19
Annex A	Warning Message Format	D-20

FLIGHT SAFETY PLAN 3-81

MET ROCKET/KWAJALEIN

1. PURPOSE: This Flight Safety Plan defines the flight safety criteria and procedures for launches of the SUPER-LOKI meteorological rocket from the Kwajalein Island Small Rocket Launch Pad.

2. SCOPE:

a. The information contained in this document applies to the following rocket motor and payload launched from the KISHA launcher on the Kwajalein Small Rocket Launch Pad:

MOTOR: SR 110-AD-1 SUPER-LOKI Rocket Motor (Ballasted Interstage)

PAYOUT: PWN-11A Instrumented Dart Payload

b. This Flight Safety Plan applies to all military and civilian agencies associated with the operation or support of Kwajalein Missile Range (KMR) activities.

c. This Flight Safety Plan is issued under the authority of the KMR Safety Manual, which should be consulted for information not contained herein.

3. POLICY: It is the policy of the Commanding Officer, Kwajalein Missile Range that every reasonable precaution consistent with operational requirements be taken to protect personnel and property during missile operations in the KMR area.

4. INTRODUCTION: The SR 110-AD-1 SUPER-LOKI rocket motor with the ballasted interstage is launched with the PWN-11A payload to gather atmospheric data for the World-Wide Weather Program and for certain missile operations at KMR. The PWN-11A payload consists of a ballute and telemetry package that is deployed at approximately 120 seconds after launch. After payload separation, the booster continues on a ballistic trajectory until impact.

5. DEFINITIONS: The following standard definitions apply to all missile launches:

a. Booster Impact Area: The booster impact area is the area under the normal flight path into which the booster will return to the surface of the earth.

b. Caution Area: The area within which special safety precautions are taken, such as sheltering or evacuation of nonessential personnel and/or clearance of aircraft and ships not in support of the operation.

c. Effective Launch Azimuth (ELA): That azimuth which would be set on the launcher to achieve a nominal impact if there were no wind and no coriolis effect.

d. Effective Quadrant Elevation (EQE): That elevation which would be set on the launcher to achieve a nominal impact if there were no wind and no coriolis effect.

e. Essential Personnel: Those individuals whose presence at their stations or working areas within a caution area during a range operation is required and has been approved by the Commanding Officer, KMR, or his designated representative, Chief, KMR Range Safety Office.

FLIGHT SAFETY PLAN 3-81

MET ROCKET/KWAJALEIN

f. Hazard Time Interval: The time duration within which the caution area is dangerous to personnel.

g. Launch Azimuth (LA): The azimuth setting of the launcher in degrees from true north.

h. Quadrant Elevation (QE): The elevation angle of the launcher with respect to the local horizontal plane.

i. Range Safety GREEN: A condition whereby precautions have been taken to ensure adequate safety and the KMR Range Safety Officer (RSO) considers the range cleared for launch. These precautions include but are not limited to: Publishing appropriate notice to airmen and mariners, surveillance of caution areas where practicable, and the evacuation or sheltering of nonessential personnel located in the booster impact area.

j. Range Safety RED: A condition whereby the KMR Range Safety Officer considers the KMR unsafe and launch operations are not allowed to continue.

k. Range Safety Officer (RSO): The individual specifically qualified and designated by the Chief, KMR Range Safety Office (RKS) to monitor and exercise control of the safety aspects of the KMR activities.

6. FLIGHT SAFETY REQUIREMENTS: The following requirements are applicable to launches of the MET Rocket from Kwajalein Island:

a. Warning messages must be sent prior to each firing, or a series of firings, in accordance with annex A. A "comeback" copy of the transmitted message is to be delivered to the KMR Range Safety Office (RKS) within 4 hours of the transmission time, unless the delivery time falls outside of normal working hours. In that case, the copy is to be delivered to RKS no later than 0930 hours the following workday.

b. Launcher calibration will be verified by Range Safety in accordance with KOP-150, Encoder and Light Bank Certification.

c. The Kwajalein Airport must be closed prior to arming at T-12 minutes. (The Federal Aviation Agency (FAA) may permit aircraft to use the runway provided they do not become airborne at the western end of the runway, or violate the caution area or the ground hazard area. After obtaining FAA approval, the helicopters and Caribous may use short-landing and take-off patterns, and other aircraft may take off towards the East.)

d. Current rawinsonde data up to 40,000 feet will be available at T-20 minutes. Readings should be made at 1-minute intervals for the first 5 minutes and at 3-minute intervals thereafter up to 40,000 feet.

e. Pilot Balloon (PIBAL) data using single theodolite solution (as a minimum) for 6 minutes to approximately 2,000 feet is required. The balloon is to be launched no earlier than T-20 minutes. Additional data may be required by the RSO in the event of holds during countdown.

FLIGHT SAFETY PLAN 3-81

MET ROCKET/KWAJALEIN

g. The Caution Area is shown in figure 1.

h.. Launch constraints:

(1) The minimum effective quadrant elevation (EQE) shall be 74 degrees.

(2) The booster is to be targeted to impact no closer than 3.2 nautical miles from the launcher on an azimuth of 250 degrees True.

7. SAFETY LAUNCH APPROVAL: The following procedures will be used in obtaining launch approval for SUPER-LOKI rocket firings from Kwajalein Island:

a. Prior to initiation of the range countdown the KMR Range Operations Office (RKT) must submit to RKS a request for launch approval. This request should contain the specific period for the conduct of the firing program, references to appropriate documentation, and any other information required to satisfy the requirements of this Flight Safety Plan.

b. RKS will review the request and issue Safety Launch Approval as appropriate. This approval may be issued for a single launch or a series of launches.

c. The range countdown will not be initiated without written Safety Launch Approval.

8. RESPONSIBILITIES FOR SAFETY ACTIONS:

a. Prior to the countdown:

(1) RKT will:

(a) Include in the weekly KMR Report of Scheduled Operations the schedule for the Met rocket firings.

(b) Notify RKS of any changes to the launch window which occur prior to initiation of the range countdown.

(c) Issue warning messages in accordance with annex A, and provide copies to RKS in accordance with paragraph 6. a.

(d) Through FAA, coordinate air traffic in accordance with the KMR/Bucholz Tower Letter of Agreement.

(2) RKS will:

(a) Ensure that the warning messages have been issued and are correct.

(b) Check the shipping density reports and check shipping activity in the Caution Areas with KMR Harbor Control and with the Trust Territory.

(c) Determine requirements for aircraft surveillance.

FLIGHT SAFETY PLAN 3-81

MET ROCKET/KWAJALEIN

b. During the countdown:

(i) RKT will:

(a) Coordinate with the RSO the commitment of range resources (boats and aircraft) that may have an impact on the safety status during the mission.

(b) Calculate launcher settings and enter the setting on the launcher.

(c) Provide weather data as specified in paragraphs 6. e. and 6. f.

(2) RKS will:

(a) Verify launcher settings are correctly calculated and set on the launcher.

(b) Evaluate problems that arise during a mission and determine the safety impact.

(c) Monitor the actions that are taken during a mission to satisfy the requirements of this Flight Safety Plan and issue a Range Safety GREEN or RED as appropriate.

9. FLIGHT SAFETY RED CRITERIA: The following criteria constitute grounds for the RSO declaring the Range RED for Safety:

- a. If launcher settings have not been calculated and verified by T-2 minutes.
- b. Nonessential ships, aircraft, or personnel are in the caution area.
- c. The RSO has reason to believe an unsafe condition exists.

10. REFERENCES:

- a. KMR Range Safety Manual.
- b. Ground Safety Plan, MET Rocket/Kwajalein.
- c. KMR/Bucholz Tower Letter of Agreement.
- d. SUPER-LOKI PWN-11A Meteorological Rocket System Range Safety Document, SDC-TM-637, 1 December 1972, Space Data Corporation.
- e. KOP-150, Encoder and Lightband Certification.
- f. SUPER-LOKI 8B Meteorological Rocket System Range Safety Document, SDC TM-521, 25 October 1971, Space Data Corporation.

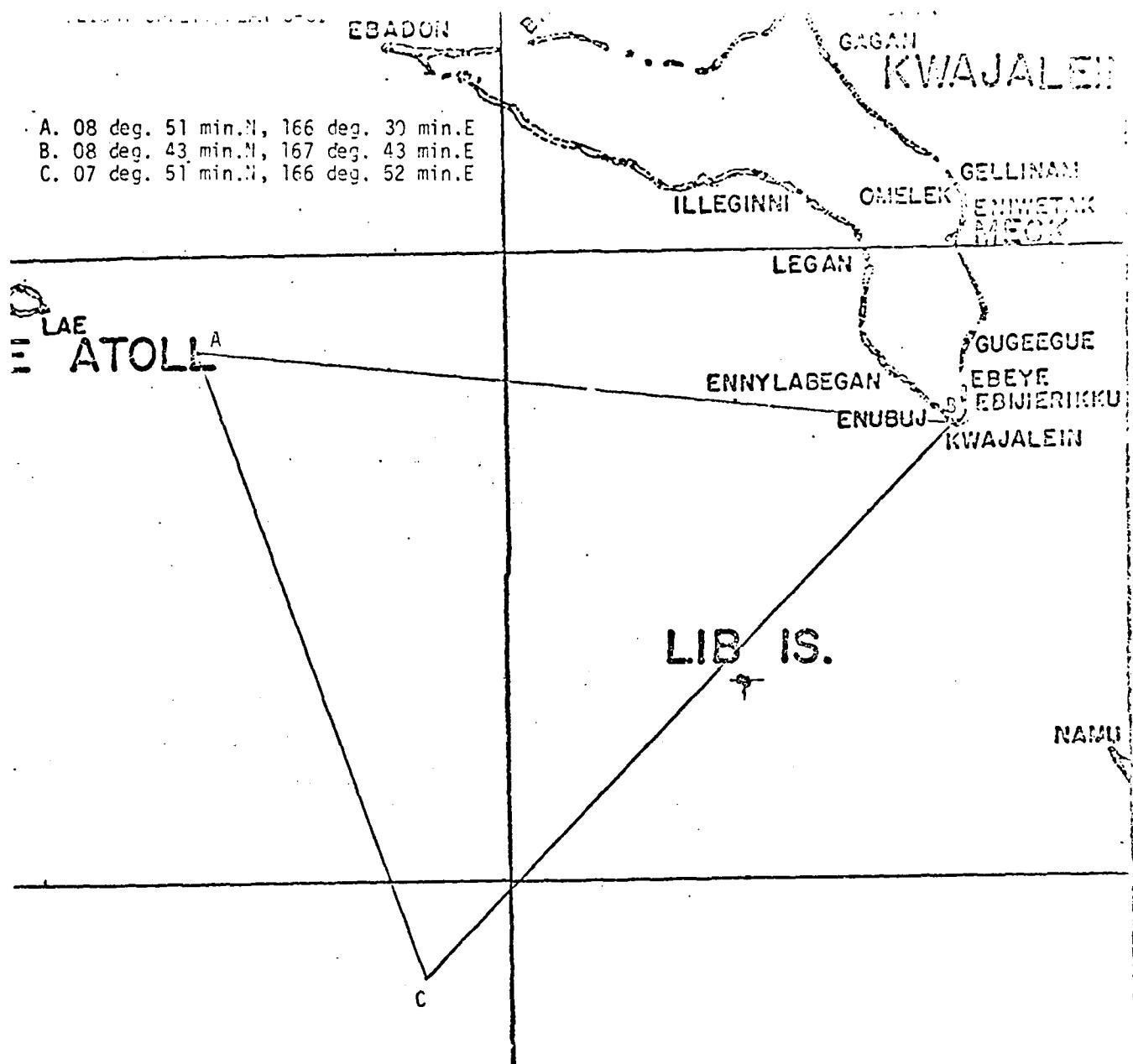


Figure 1. Met Rocket Caution Area

## ANNEX A

## WARNING MESSAGE FORMAT

The following warning message will be forwarded by RKT. RKS will receive an information copy of each message. The hazard time interval will be specified to ensure that 30 minutes is allowed prior to the opening of the launch window and that an additional 30 minutes is added to the close of the window. These times are required to ensure that the range is safe for a launch and to allow time for all debris to impact prior to releasing the caution area restrictions.

<u>FOR</u>	<u>MESSAGE FORMAT</u>	<u>METHOD AND ADDRESSEE</u>
Government Marshall Islands	See appendix 1	Message is transmitted by TWX to the Government, Marshall Islands in Majuro at least 48 hours prior to the operation. Message should specify only the launch day unless the following day(s) has been definitely established as a contingency day(s).
Local Notifications	See text in appendix 1	<ul style="list-style-type: none"> <li>a. Pass to Base Radio (Kwajalein control) 2 days prior to the operation.</li> <li>b. Publish in HourGlass the day before the operation.</li> <li>c. Announce on the Tarlang (Ebeye Ferry) the day before and the day of the operation.</li> <li>d. Announce over AFRS Kwajalein on the day before and the day of the operation.</li> </ul>

FLIGHT SAFETY PLAN 3-81  
ANNEX A

MET ROCKET/KWAJALEIN

APPENDIX 1 TO ANNEX A

GOVERNMENT MARSHALLS FORMAT

1. KMR WILL CONDUCT HAZARDOUS MISSILE OPERATIONS DURING THE TIME INTERVALS  
TO \_\_\_\_\_ AND \_\_\_\_\_ TO \_\_\_\_\_ WITHIN AN AREA CON-  
TAINED BETWEEN THE AZIMUTHS OF 225 DEGREES TRUE TO 275 DEGREES TRUE FROM  
KWAJALEIN ISLAND AND EXTENDING OUT TO A RANGE OF 75 NAUTICAL MILES.
2. VESSELS SHOULD NOT ENTER OR MOVE WITHIN THE HAZARD AREA DURING THE PERIOD  
INDICATED IN PARAGRAPH 1 WITHOUT CONTACTING KWAJALEIN BASE RADIO ON THE FRE-  
QUENCIES OF 2716KHZ OR 500KHZ.
3. AN ALL-CLEAR MESSAGE WILL BE TRANSMITTED ASAP AFTER THE OPERATION.
4. OPERATION DESIGNATOR IS OP \_\_\_\_\_.

**Appendix E**

**AIR DIVISION (AD)  
ROCKET SAFETY**

**(EXCERPTS FROM SAFETY SUPPORT PLAN - VERTICAL  
PROBE LAUNCHES AND IMPACT PREDICTIONS USING  
WIND WEIGHTING FACTOR METHOD)**

**SAFETY SUPPORT PLAN**

**VERTICAL PROBE  
LAUNCHES**

James R. Williford  
Safety Analysis Division

13 February 1976

## SAFETY SUPPORT PLAN

### VERTICAL PROBE LAUNCHES

#### I. Mission Description

Vertical probes (sounding rockets) are launched from Test Site A-15A for the purpose of gathering upper atmosphere physical properties data. These probes range in complexity from small single stage meteorological rockets to highly sophisticated multistage vehicles. They are capable of attaining altitudes up to 400 nautical miles and downrange impact distances up to 500 nautical miles.

AD Range Safety analysts are responsible for establishing probe launch safety criteria and ballistic calculations for launcher settings. The AD computer program used for the ballistic calculations is P0927. This program computes the launcher setting angles (azimuth and elevation) for launch time wind conditions to achieve a preplanned no-wind impact point. These calculations are updated throughout the launch time period.

Future vertical probe launches will be controlled from Site A-27 utilizing the Consolidated Eglin Real-Time System (CERTS). This document describes the safety support requirements necessary for the launches of vertical probes.

#### II. Support Requirements

##### A. Communications Requirements

1. Fixed communications network between Sites A-27 and A-15A launch control facility.
2. Air to ground radio for surveillance aircraft (monitor only).
3. Fixed communication between Site A-27 and Pilot Balloon (PIBAL) launch site.

##### B. Radar Requirements

1. FPS-16 for booster tracking (skin track).
2. FPS-16 for payload stage tracking (skin track).
3. FPS-16 for surveillance aircraft tracking (beacon track).

NOTE: This radar can be one of the radars used to track the probe since surveillance will take place prior to first launch.

##### C. Surveillance Requirements. One surface radar equipped aircraft for surveillance of water range impact areas.

#### D. IDI Display Requirements

##### 1. Background map size definition

<u>Map No.</u>		<u>Latitude</u>	<u>Longitude</u>
1	min.	29°53'00"	86°19'00"
	max.	30°30'00"	87°00'00"
2	min.	29°30'00"	86°00'00"
	max.	30°30'00"	87°00'00"
3	min.	29°00'00"	87°37'00"
	max.	30°30'00"	87°41'00"
4	min.	28°30'00"	85°25'00"
	max.	30°30'00"	87°41'00"
5	min.	28°00'00"	85°00'09"
	max.	30°30'00"	87°58'00"
6	min.	27°30'00"	84°53'00"
	max.	30°30'00"	88°14'00"
7	min.	25°00'00"	83°33'00"
	max.	30°30'00"	89°35'00"
8	min.		
	max.		

##### 2. Graphic displays

- a. Present position of range surveillance aircraft while airborne; ship positions marked.
- b. Launch Site A-15A denoted.
- c. Present position of booster stage to impact.
- d. Present position of payload stage to impact.
- e. Ballistic instantaneous impact prediction (IIP) of payload stage.

The following graphic presentations will be entered from the console keyboard:

- f. Planned flight azimuth.
- g. Booster and payload stages planned impact points.
- h. Booster and payload stages 3-sigma impact areas (circle or ellipse).

3. Alphanumeric displays

- a. Altitude of payload stage (Altitude P).
- b. Altitude of booster stage (Altitude S).
- c. Mach of payload stage (Mach P).
- d. Mach of booster stage (Mach S).
- e. Downrange distance of booster stage from Site A-15A.
- f. Downrange distance of payload stage from Site A-15A.
- g. Course of booster stage.
- h. Course of payload stage.

E. Secondary Data Display System

1. The secondary data display system map displays are defined in figures 1 through 8 .

2. The time history and vertical plane displays are defined in figures 9 and 10.

III. Concept of Operation

AD computer program P0927 computes the launcher setting angles (azimuth and elevation) for launch time wind conditions to achieve a preplanned no-wind impact point. The input data for this program consists of the following card decks:

Job Control Cards  
PIBAL Wind Cards  
Tower Wind Cards  
Rawinsonde Cards  
Rocket Data Cards

Additionally, a magnetic tape which contains a large quantity of rocket physical data is attached in the input stream. This tape is presently attached through the permanent file name "ROCKETDATADECKS".

The method of operating the program for mission support is as follows. The magnetic tape containing the rocket(s) physical data is prepared in advance of the launch day with data supplied by the range user. The rawinsonde deck is created hour(s) prior to the first scheduled launch. This data is obtained from the Meteorological Detachment's computer file. A special rawinsonde survey may be required for mission support to obtain the most current wind profile. The rocket data deck is prepared prior to launch day. The PIBAL and tower wind decks are updated periodically (every 20 to 30 minutes) prior to and during the launch period. The support operation during the launch period consists of maintaining current wind profile data and executing P0927 with this data. Appendix I contains the description of the computer deck setup to execute the program.

#### IV. Deficiencies

A. The use of Site A-27 to support the launches of vertical probes calls for a means of remotely executing P0927, which is a non-real-time program, from the control room. At present, there are no facilities available to execute a non-real-time program from the control room. The most direct solution to this deficiency is the installation of remote terminal facilities in the A-27 control room. The Texas Instrument portable or the CDC CRT-type terminals could be used. In either case, the appropriate terminal-computer communications between the A-27 control room and the CDC 6600 would have to be installed. A minimum of two remote terminals would be required.

B. A deficiency exists in the alphanumeric display capability of the primary data system for vertical probe launches. It would be desirable to have displayed in alpha-numerics the downrange distances in nautical miles of the booster and payload stages from the launch point. These displays are called for in paragraphs II. D. 3. (e) and (f). It is recommended that these deficiencies be eliminated prior to the next series of probe launches.

PAYLOAD

X - - -  
Y - - -  
H - - -

Present Position - Ground Plane

Target Point - Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

Release Point  
Range to target (yds) \_\_\_\_\_

Run in heading \_\_\_\_\_  
Length of run in line (yds)  
Abort, clear to fire and destruct lines.

Initial point - Latitude	_____	Pt 1	Pt 2	Pt 3	Pt 4	Pt 5
Longitude	_____	_____	_____	_____	_____	_____
Line segment bearing	_____	_____	_____	_____	_____	_____
Line segment length (yds)	_____	_____	_____	_____	_____	_____

PAYLOAD

SPEED  
HEADING  
- - -

BOOSTER  
X - - -  
Y - - -  
H - - -

SPEED  
HEADING  
# - - -

PROJECT  
MISSION  
DATE - - -

PRESENTATION



Present Position - Ground Plane	Target Point - Latitude _____	Release Point _____
	Longitude _____	Range to target (yds) _____
Run in heading	Length of run in line (yds)	Abort, clear to fire and destruct lines
X - - - -	Pt. 1	Pt. 2
Y - - - -	Pt. 3	Pt. 4
Z - - - -	Pt. 5	
Payload	Initial point - Latitude	
	Longitude	
	Line segment bearing	
	Line segment length (yds)	

PAYLOAD -

X - - - -  
Y - - - -  
Z - - - -

Payload -

SPEED -  
HEADING  
- - - -

BOOSTER -

X - - - -  
Y - - - -  
Z - - - -

BOOSTER -

SPEED -  
HEADING  
- - - -

PROJECT -  
MISSION -  
DATE - - - -

PRESENTATION -

CENTER PT (YDS FROM A-20)

N =

S = 91141.

Figure 3.

RADIUS (YDS) = 103234.

<u>P</u> <u>A</u> <u>Y</u> <u>L</u> <u>O</u> <u>A</u> <u>D</u>	Present Position - Ground Plane Target Point - Latitude _____ Longitude _____ Run in heading _____ Length of run in line (yds) _____ Abort, clear to fire and destruct lines.	Release Point Range to target (yds) Pt 1 Pt 2 Pt 3 Pt 4 Pt 5 Initial point - Latitude _____ Longitude _____ Line segment bearing _____ Line segment length (yds) _____
--	--	--

RADIUS (yds) = 133674.  
 N = 121522  
 Figure 4.

CENTER PT (yds from A-20)

POOSTER -  
 X - - -  
 Y - - -  
 U - - -  
SPEE  
HEDING  
 - - - - -

POOSTER -  
 X - - -  
 Y - - -  
 U - - -  
SPEE  
HEDING  
 - - - - -

PROJET  
MISSINU  
DATE  
 - - - - -

PRESENTATIO  
 - - - - -

<u>Payload</u>	X - - - -	Y - - - -	Z - - - -	Present Position - Ground Plane	Target Point - Latitude -	Longitude -	Release Point	Range to target (yds)
	Run in heading	Length of run in line (yds)						
	Abort, clear to fire and destruct lines.			Pt 1	Pt 2	Pt 3	Pt 4	Pt 5
<u>Initial point</u>	- Latitude	Longitude						
<u>Line segment bearing</u>								
<u>Line segment length (yds)</u>								

Booster -

X - - - -  
Y - - - -  
Z - - - -

Payload -

SPEED -  
FERRING -  
- - - -

Booster -

X - - - -  
Y - - - -  
Z - - - -

Booster -

SPEED -  
FERRING -  
- - - -

PROJECT - - - -  
MISSION - - - -  
DATE - - - -

Presentation -

N = 8 = 151902.  
CENTER PT (YDS FROM A-20)

RADIUS (YDS) = 162029.

Figure 5.

PAYLOAD -

X - - -  
Y - - -  
H - - -

PAYLOAD -

SPEED  
HEADING  
- - -

BOOSTER -

X - - -  
Y - - -  
H - - -

BOOSTER -

SPEED  
HEADING  
- - -

PROJECT - - -  
MISSION - - -  
DATE - - -

PRESENTATION -

N = S = 202537.  
Figure 6.

Present Position - Ground Plane

Target Point - Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

Release Point  
Range to target (yds) \_\_\_\_\_

Run in heading \_\_\_\_\_  
Length of run in line (yds)

Abort, clear to fire and destruct lines.

Initial point - Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

Line segment bearing \_\_\_\_\_  
Line segment length (yds) \_\_\_\_\_

Pt 1 Pt 2 Pt 3 Pt 4 Pt 5

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RADIUS (yds) = 222790.

Present Position - Ground Plane	Latitude _____	Release Point	Range to target (yds) _____
Target Point - Latitude _____	Longitude _____		
Run in heading _____	Length of run in line (yds) _____		
X - - -	Abort, clear to fire and destruct lines.		
Y - - -	Pt 1	Pt 2	Pt 5
H - - -			
<u>PAYLOAD</u> -	Initial point - Latitude _____	Pt 3	Pt 4
X - - -	Longitude _____		
Y - - -			
Z - - -			
<u>PAYLOAD</u> -	Line segment bearing _____		
X - - -	Line segment length (yds) _____		
Y - - -			
Z - - -			
<u>SPEED</u> -			
<u>HEADNG</u> -			
<u>BOOSTER</u> -			
<u>SPEED</u> -			
<u>HEADNG</u> -			
<u>PRESENTATION</u> -			

RADIUS (YDS) = 324058.

CENTER PT (YDS FROM A-20)

N = S = 303805.

W = R = ~

Figure 7.

PAYLOAD -

X - - -  
Y - - -  
H - - -

PAYLOAD -

X - - -  
Y - - -  
H - - -

BOOSTER -

X - - -  
Y - - -  
H - - -

BOOSTER -

X - - -  
Y - - -  
H - - -

PROJECT - - - - -  
MISSION - - - - -  
DATE - - - - -

P  
A  
Y  
L  
O  
A  
D

X - - -  
Y - - -  
L - - -  
H - - -

P  
A  
Y  
L  
O  
A  
D

SPECIFIED  
HEADING  
- - -

B  
O  
O  
S  
T  
E  
R

SPECIFIED  
HEADING  
- - -

B  
O  
O  
S  
T  
E  
R

SPECIFIED  
HEADING  
- - -

PROJECT - - -  
MISSION - - -  
DATE - - -

P  
R  
E  
S  
M  
N  
T  
A  
T  
I  
O  
N

Present Position - Ground Plane

Target Point - Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

Run in heading \_\_\_\_\_  
Length of run in line (yds) \_\_\_\_\_

Abort, clear to fire and destruct lines.

Initial point - Latitude \_\_\_\_\_  
Longitude \_\_\_\_\_

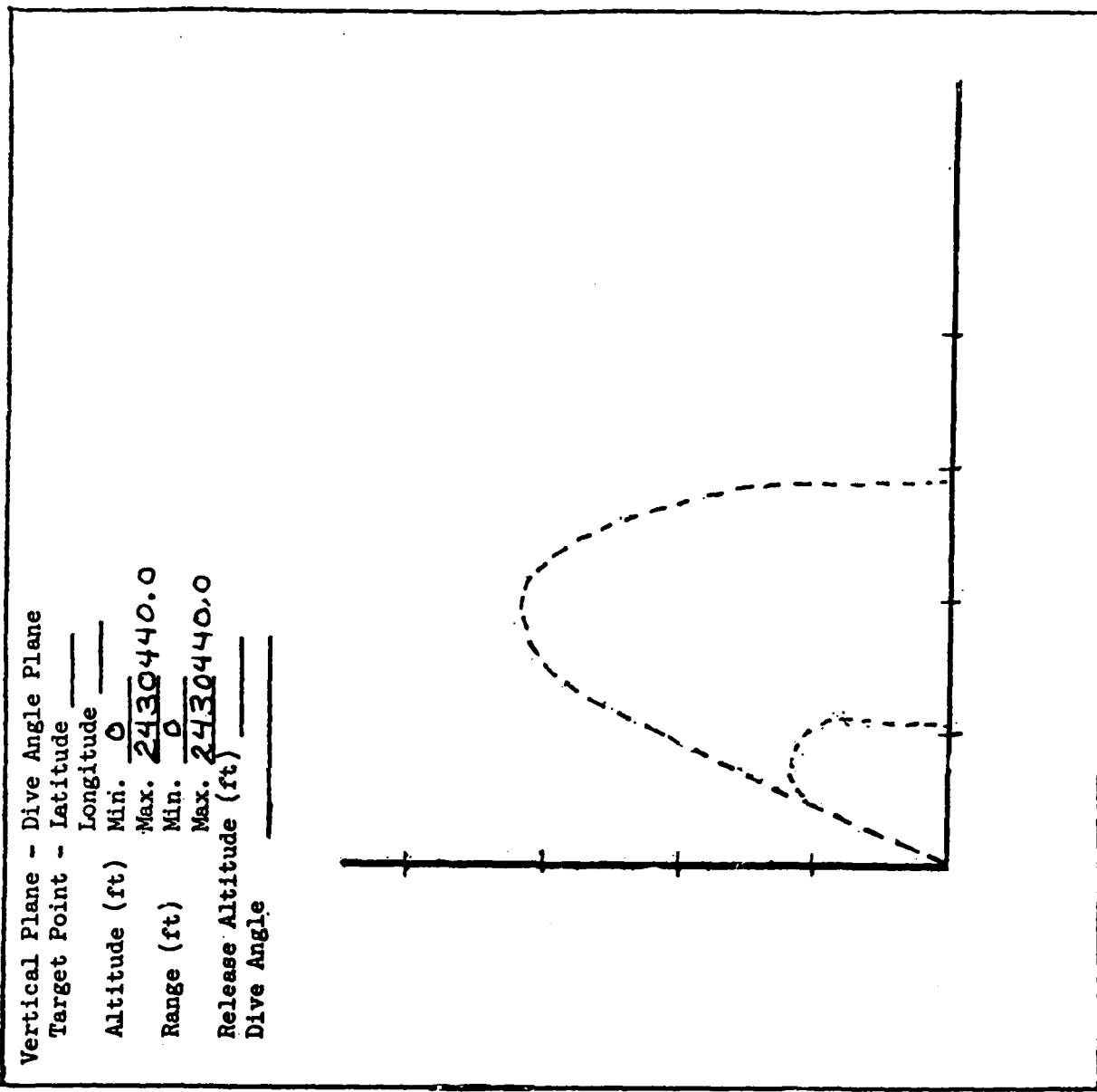
Line segment bearing \_\_\_\_\_  
Line segment length (yds) \_\_\_\_\_

Release Point  
Range to target (yds) \_\_\_\_\_

RADIUS (yds) = 425327.

CENTER PT (yds from A-20)  
N = 8 = 405073.  
E = 0

Fire 8.



PAYLOAD - -

X - - -  
Y - - -  
H - - -

PAYLOAD - -

SPEED  
HEADING  
- - - -

Booster -

X - - - -  
Y - - - -  
H - - - -

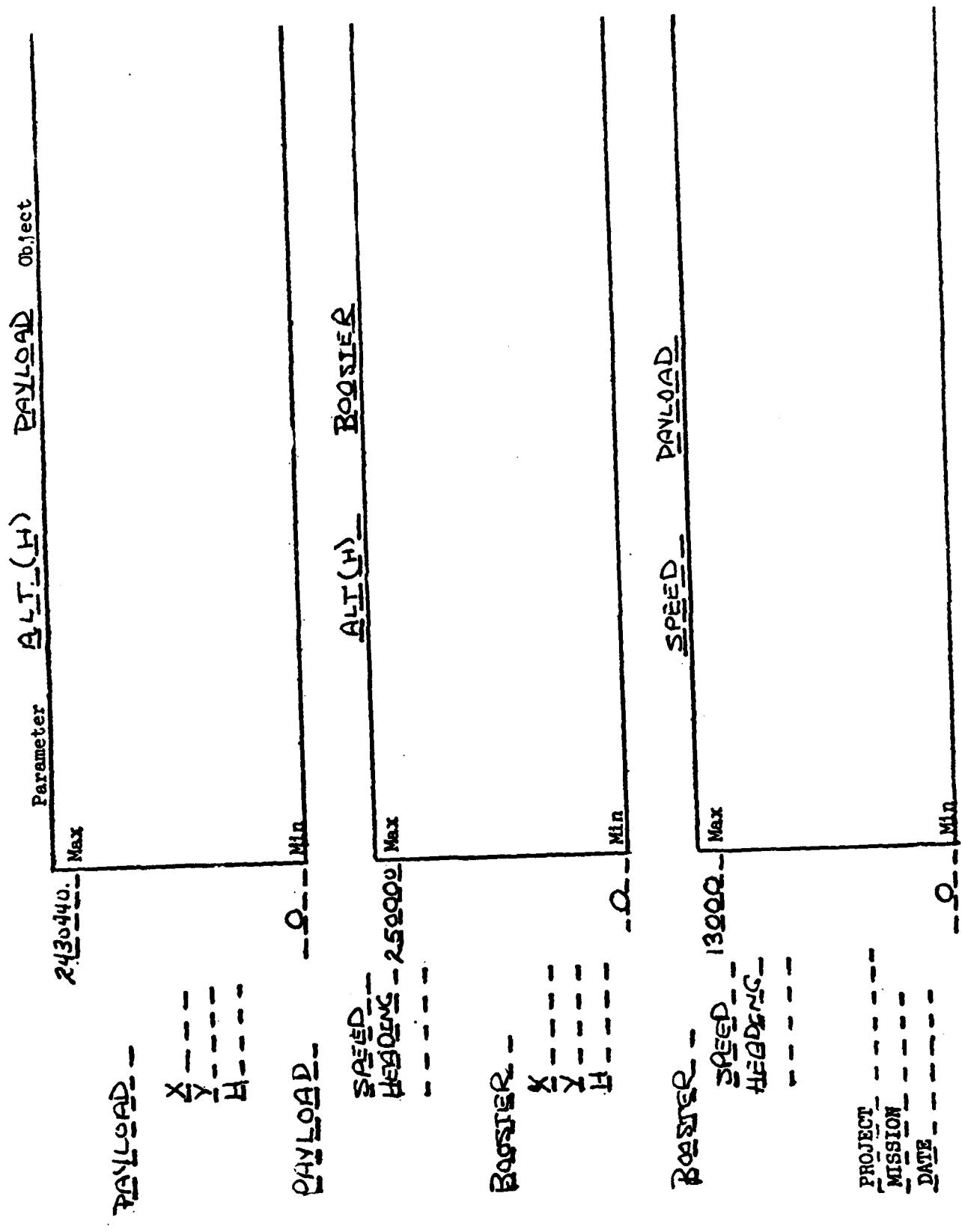
Booster -

SPEED  
HEADING  
- - - -

PROJECT - - - -  
MISSION - - - -  
DATE - - - -

PRESENTATION - - -

Figure 9.



## APPENDIX I

An example of the data deck setup to execute P0927 from a remote terminal is shown in table I. The discussion in this appendix is limited to a general description of the data deck setup. For a more concise definition of terms and formats, one should refer to the P0927 Users Instructions.

The data deck shown in table I must be created in entirety prior to the first launch. Once this deck has been created, the proper use of the remote terminal intercom commands in manipulating files gives the ballistitian greater flexibility in maintaining files with current wind data for several different rockets simultaneously. This is discussed below.

Lines 50 through 81 of table I are the job control cards. These cards contain the necessary information to execute a batch job from the remote terminal. Line 70 attaches the tape "ROCKETDECKS" into the input stream as discussed earlier.

Lines 100 through 260 are the PIBAL wind data cards. These cards are produced from data gathered during the flight of the PIBAL. This data is from transit readings from two different stations of the balloon position. The data is given directly to the ballistitian via telephone at the PIBAL launch site. The information is copied down on the data sheet shown in figure 1. This data sheet is in the form of the format compatible to the input requirement.

Lines 270 through 290 are the tower windspeed and direction cards. This information is gathered from a fixed 300 foot tower at the launch site. Line 270 gives the height of the tower readings, i.e., 52, 179, and 253 feet. Line 280 gives the windspeeds at those heights, in this case, 10, 8, and 9 knots. Line 290 gives the wind direction, in this case 070°, 070°, and 070°.

Lines 300 through 380 contain the rawinsonde information - altitude, speed, and direction.

Lines 390 through 431 contain rocket physical data. The reader should refer to the P0927 User Instructions for the definition of the terms in this group of cards.

For one particular rocket, once the deck has been setup in the form of table I, updating the deck with new PIBAL readings is done by deleting lines 100 through 260 and inserting the new readings in this block. The same is true for the tower readings, lines 270 through 290.

Decks for other rockets can be generated by changing lines 390 through 430. Consequently, the task of generating data decks for several rockets consist of creating the first deck as in table I and updating it by deleting and reinserting new data in the appropriate blocks.

A sample output of the program is shown in table II. In this case the desired effective quadrant elevation (EQE) angle was  $84^\circ$  and the desired azimuth was  $160^\circ$ . The program first lists the wind profile which is a merger of the tower, PIBAL, and rawinsonde wind profiles. The subsequent information listed is intermediate iterations that the program goes through to arrive at the final result. In this particular case, to achieve an EQE of  $84^\circ$  and an azimuth of  $160^\circ$ , with the wind profile listed, the launch must be set at an elevation angle of  $83.29^\circ$  and an azimuth of  $162.51^\circ$ .

TABLE I.

TABLE II.

*NEKE-100Q.*

TIME	STAGE	ALT.	VEL.	ANGLE	ALT.	VEL.	ANGLE
000.	1	1000.	10000.	15.4	10000.	10000.	15.4
100.	1	1000.	10000.	15.4	1000.	1000.	15.4
200.	1	2000.	10000.	14.3	2000.	10000.	14.3
300.	1	3000.	10000.	13.2	3000.	10000.	13.2
400.	1	4000.	10000.	12.0	4000.	10000.	12.0
500.	1	5000.	10000.	10.8	5000.	10000.	10.8
600.	1	6000.	10000.	9.6	6000.	10000.	9.6
700.	1	7000.	10000.	8.4	7000.	10000.	8.4
800.	1	8000.	10000.	7.2	8000.	10000.	7.2
900.	1	9000.	10000.	6.0	9000.	10000.	6.0
1000.	1	10000.	10000.	5.0	10000.	10000.	5.0
1100.	1	11000.	10000.	4.0	11000.	10000.	4.0
1200.	1	12000.	10000.	3.0	12000.	10000.	3.0
1300.	1	13000.	10000.	2.0	13000.	10000.	2.0
1400.	1	14000.	10000.	1.0	14000.	10000.	1.0
1500.	1	15000.	10000.	0.0	15000.	10000.	0.0
1600.	1	16000.	10000.	-1.0	16000.	10000.	-1.0
1700.	1	17000.	10000.	-2.0	17000.	10000.	-2.0
1800.	1	18000.	10000.	-3.0	18000.	10000.	-3.0
1900.	1	19000.	10000.	-4.0	19000.	10000.	-4.0
2000.	1	20000.	10000.	-5.0	20000.	10000.	-5.0
2100.	1	21000.	10000.	-6.0	21000.	10000.	-6.0
2200.	1	22000.	10000.	-7.0	22000.	10000.	-7.0
2300.	1	23000.	10000.	-8.0	23000.	10000.	-8.0
2400.	1	24000.	10000.	-9.0	24000.	10000.	-9.0
2500.	1	25000.	10000.	-10.0	25000.	10000.	-10.0
2600.	1	26000.	10000.	-11.0	26000.	10000.	-11.0
2700.	1	27000.	10000.	-12.0	27000.	10000.	-12.0
2800.	1	28000.	10000.	-13.0	28000.	10000.	-13.0
2900.	1	29000.	10000.	-14.0	29000.	10000.	-14.0
3000.	1	30000.	10000.	-15.0	30000.	10000.	-15.0
3100.	1	31000.	10000.	-16.0	31000.	10000.	-16.0
3200.	1	32000.	10000.	-17.0	32000.	10000.	-17.0
3300.	1	33000.	10000.	-18.0	33000.	10000.	-18.0
3400.	1	34000.	10000.	-19.0	34000.	10000.	-19.0
3500.	1	35000.	10000.	-20.0	35000.	10000.	-20.0
3600.	1	36000.	10000.	-21.0	36000.	10000.	-21.0
3700.	1	37000.	10000.	-22.0	37000.	10000.	-22.0
3800.	1	38000.	10000.	-23.0	38000.	10000.	-23.0
3900.	1	39000.	10000.	-24.0	39000.	10000.	-24.0
4000.	1	40000.	10000.	-25.0	40000.	10000.	-25.0
4100.	1	41000.	10000.	-26.0	41000.	10000.	-26.0
4200.	1	42000.	10000.	-27.0	42000.	10000.	-27.0
4300.	1	43000.	10000.	-28.0	43000.	10000.	-28.0
4400.	1	44000.	10000.	-29.0	44000.	10000.	-29.0
4500.	1	45000.	10000.	-30.0	45000.	10000.	-30.0
4600.	1	46000.	10000.	-31.0	46000.	10000.	-31.0
4700.	1	47000.	10000.	-32.0	47000.	10000.	-32.0
4800.	1	48000.	10000.	-33.0	48000.	10000.	-33.0
4900.	1	49000.	10000.	-34.0	49000.	10000.	-34.0
5000.	1	50000.	10000.	-35.0	50000.	10000.	-35.0
5100.	1	51000.	10000.	-36.0	51000.	10000.	-36.0
5200.	1	52000.	10000.	-37.0	52000.	10000.	-37.0
5300.	1	53000.	10000.	-38.0	53000.	10000.	-38.0
5400.	1	54000.	10000.	-39.0	54000.	10000.	-39.0
5500.	1	55000.	10000.	-40.0	55000.	10000.	-40.0
5600.	1	56000.	10000.	-41.0	56000.	10000.	-41.0
5700.	1	57000.	10000.	-42.0	57000.	10000.	-42.0
5800.	1	58000.	10000.	-43.0	58000.	10000.	-43.0
5900.	1	59000.	10000.	-44.0	59000.	10000.	-44.0
6000.	1	60000.	10000.	-45.0	60000.	10000.	-45.0
6100.	1	61000.	10000.	-46.0	61000.	10000.	-46.0
6200.	1	62000.	10000.	-47.0	62000.	10000.	-47.0
6300.	1	63000.	10000.	-48.0	63000.	10000.	-48.0
6400.	1	64000.	10000.	-49.0	64000.	10000.	-49.0
6500.	1	65000.	10000.	-50.0	65000.	10000.	-50.0
6600.	1	66000.	10000.	-51.0	66000.	10000.	-51.0
6700.	1	67000.	10000.	-52.0	67000.	10000.	-52.0
6800.	1	68000.	10000.	-53.0	68000.	10000.	-53.0
6900.	1	69000.	10000.	-54.0	69000.	10000.	-54.0
7000.	1	70000.	10000.	-55.0	70000.	10000.	-55.0
7100.	1	71000.	10000.	-56.0	71000.	10000.	-56.0
7200.	1	72000.	10000.	-57.0	72000.	10000.	-57.0
7300.	1	73000.	10000.	-58.0	73000.	10000.	-58.0
7400.	1	74000.	10000.	-59.0	74000.	10000.	-59.0
7500.	1	75000.	10000.	-60.0	75000.	10000.	-60.0
7600.	1	76000.	10000.	-61.0	76000.	10000.	-61.0
7700.	1	77000.	10000.	-62.0	77000.	10000.	-62.0
7800.	1	78000.	10000.	-63.0	78000.	10000.	-63.0
7900.	1	79000.	10000.	-64.0	79000.	10000.	-64.0
8000.	1	80000.	10000.	-65.0	80000.	10000.	-65.0
8100.	1	81000.	10000.	-66.0	81000.	10000.	-66.0
8200.	1	82000.	10000.	-67.0	82000.	10000.	-67.0
8300.	1	83000.	10000.	-68.0	83000.	10000.	-68.0
8400.	1	84000.	10000.	-69.0	84000.	10000.	-69.0
8500.	1	85000.	10000.	-70.0	85000.	10000.	-70.0
8600.	1	86000.	10000.	-71.0	86000.	10000.	-71.0
8700.	1	87000.	10000.	-72.0	87000.	10000.	-72.0
8800.	1	88000.	10000.	-73.0	88000.	10000.	-73.0
8900.	1	89000.	10000.	-74.0	89000.	10000.	-74.0
9000.	1	90000.	10000.	-75.0	90000.	10000.	-75.0
9100.	1	91000.	10000.	-76.0	91000.	10000.	-76.0
9200.	1	92000.	10000.	-77.0	92000.	10000.	-77.0
9300.	1	93000.	10000.	-78.0	93000.	10000.	-78.0
9400.	1	94000.	10000.	-79.0	94000.	10000.	-79.0
9500.	1	95000.	10000.	-80.0	95000.	10000.	-80.0
9600.	1	96000.	10000.	-81.0	96000.	10000.	-81.0
9700.	1	97000.	10000.	-82.0	97000.	10000.	-82.0
9800.	1	98000.	10000.	-83.0	98000.	10000.	-83.0
9900.	1	99000.	10000.	-84.0	99000.	10000.	-84.0
10000.	1	100000.	10000.	-85.0	100000.	10000.	-85.0
10100.	1	101000.	10000.	-86.0	101000.	10000.	-86.0
10200.	1	102000.	10000.	-87.0	102000.	10000.	-87.0
10300.	1	103000.	10000.	-88.0	103000.	10000.	-88.0
10400.	1	104000.	10000.	-89.0	104000.	10000.	-89.0
10500.	1	105000.	10000.	-90.0	105000.	10000.	-90.0
10600.	1	106000.	10000.	-91.0	106000.	10000.	-91.0
10700.	1	107000.	10000.	-92.0	107000.	10000.	-92.0
10800.	1	108000.	10000.	-93.0	108000.	10000.	-93.0
10900.	1	109000.	10000.	-94.0	109000.	10000.	-94.0
11000.	1	110000.	10000.	-95.0	110000.	10000.	-95.0
11100.	1	111000.	10000.	-96.0	111000.	10000.	-96.0
11200.	1	112000.	10000.	-97.0	112000.	10000.	-97.0
11300.	1	113000.	10000.	-98.0	113000.	10000.	-98.0
11400.	1	114000.	10000.	-99.0	114000.	10000.	-99.0
11500.	1	115000.	10000.	-100.0	115000.	10000.	-100.0
11600.	1	116000.	10000.	-101.0	116000.	10000.	-101.0
11700.	1	117000.	10000.	-102.0	117000.	10000.	-102.0
11800.	1	118000.	10000.	-103.0	118000.	10000.	-103.0
11900.	1	119000.	10000.	-104.0	119000.	10000.	-104.0
12000.	1	120000.	10000.	-105.0	120000.	10000.	-105.0
12100.	1	121000.	10000.	-106.0	121000.	10000.	-106.0
12200.	1	122000.	10000.	-107.0	122000.	10000.	-107.0
12300.	1	123000.	10000.	-108.0	123000.	10000.	-108.0
12400.	1	124000.	10000.	-109.0	124000.	10000.	-109.0
12500.	1	125000.	10000.	-110.0	125000.	10000.	-110.0
12600.	1	126000.	10000.	-111.0	126000.	10000.	-111.0
12700.	1	127000.	10000.	-112.0	127000.	10000.	-112.0
12800.	1	128000.	10000.	-113.0	128000.	10000.	-113.0
12900.	1	129000.	10000.	-114.0	129000.	10000.	-114.0
13000.	1	130000.	10000.	-115.0	130000.	10000.	-115.0
13100.	1	131000.	10000.	-116.0	131000.	10000.	-116.0
13200.	1	132000.	10000.	-117.0	132000.	10000.	-117.0
13300.	1	133000.	10000.	-118.0	133000.	10000.	-118.0
13400.	1	134000.	10000.	-119.0	134000.	10000.	-119.0
13500.	1	135000.	10000.	-120.0	135000.	10000.	-120.0
13600.	1	136000.	10000.	-121.0	136000.	10000.	-121.0
13700.	1	137000.	10000.	-122.0	137000.	10000.	-122.0
13800.	1	138000.	10000.	-123.0	138000.	10000.	-123.0
13900.	1	139000.	10000.	-124.0	139000.	10000.	-124.0
14000.	1	140000.	10000.</td				

TABLE II. (con.)

CURRENT SETT FOR LAUNCHER		ELEVATION	SIDE	REINHUTH	ALTITUDE
TIME	- RINGE				
100.00				162.00	
100.12				169.12	
100.16				169.16	
100.18				169.18	
100.20				169.20	
100.22				169.22	
100.24				169.24	
100.26				169.26	
100.28				169.28	
100.30				169.30	
100.32				169.32	
100.34				169.34	
100.36				169.36	
100.38				169.38	
100.40				169.40	
100.42				169.42	
100.44				169.44	
100.46				169.46	
100.48				169.48	
100.50				169.50	
100.52				169.52	
100.54				169.54	
100.56				169.56	
100.58				169.58	
100.60				169.60	
100.62				169.62	
100.64				169.64	
100.66				169.66	
100.68				169.68	
100.70				169.70	
100.72				169.72	
100.74				169.74	
100.76				169.76	
100.78				169.78	
100.80				169.80	
100.82				169.82	
100.84				169.84	
100.86				169.86	
100.88				169.88	
100.90				169.90	
100.92				169.92	
100.94				169.94	
100.96				169.96	
100.98				169.98	
101.00				170.00	
101.02				170.02	
101.04				170.04	
101.06				170.06	
101.08				170.08	
101.10				170.10	
101.12				170.12	
101.14				170.14	
101.16				170.16	
101.18				170.18	
101.20				170.20	
101.22				170.22	
101.24				170.24	
101.26				170.26	
101.28				170.28	
101.30				170.30	
101.32				170.32	
101.34				170.34	
101.36				170.36	
101.38				170.38	
101.40				170.40	
101.42				170.42	
101.44				170.44	
101.46				170.46	
101.48				170.48	
101.50				170.50	
101.52				170.52	
101.54				170.54	
101.56				170.56	
101.58				170.58	
101.60				170.60	
101.62				170.62	
101.64				170.64	
101.66				170.66	
101.68				170.68	
101.70				170.70	
101.72				170.72	
101.74				170.74	
101.76				170.76	
101.78				170.78	
101.80				170.80	
101.82				170.82	
101.84				170.84	
101.86				170.86	
101.88				170.88	
101.90				170.90	
101.92				170.92	
101.94				170.94	
101.96				170.96	
101.98				170.98	
102.00				171.00	
102.02				171.02	
102.04				171.04	
102.06				171.06	
102.08				171.08	
102.10				171.10	
102.12				171.12	
102.14				171.14	
102.16				171.16	
102.18				171.18	
102.20				171.20	
102.22				171.22	
102.24				171.24	
102.26				171.26	
102.28				171.28	
102.30				171.30	
102.32				171.32	
102.34				171.34	
102.36				171.36	
102.38				171.38	
102.40				171.40	
102.42				171.42	
102.44				171.44	
102.46				171.46	
102.48				171.48	
102.50				171.50	
102.52				171.52	
102.54				171.54	
102.56				171.56	
102.58				171.58	
102.60				171.60	
102.62				171.62	
102.64				171.64	
102.66				171.66	
102.68				171.68	
102.70				171.70	
102.72				171.72	
102.74				171.74	
102.76				171.76	
102.78				171.78	
102.80				171.80	
102.82				171.82	
102.84				171.84	
102.86				171.86	
102.88				171.88	
102.90				171.90	
102.92				171.92	
102.94				171.94	
102.96				171.96	
102.98				171.98	
103.00				172.00	
103.02				172.02	
103.04				172.04	
103.06				172.06	
103.08				172.08	
103.10				172.10	
103.12				172.12	
103.14				172.14	
103.16				172.16	
103.18				172.18	
103.20				172.20	
103.22				172.22	
103.24				172.24	
103.26				172.26	
103.28				172.28	
103.30				172.30	
103.32				172.32	
103.34				172.34	
103.36				172.36	
103.38				172.38	
103.40				172.40	
103.42				172.42	
103.44				172.44	
103.46				172.46	
103.48				172.48	
103.50				172.50	
103.52				172.52	
103.54				172.54	
103.56				172.56	
103.58				172.58	
103.60				172.60	
103.62				172.62	
103.64				172.64	
103.66				172.66	
103.68				172.68	
103.70				172.70	
103.72				172.72	
103.74				172.74	
103.76				172.76	
103.78				172.78	
103.80				172.80	
103.82				172.82	
103.84				172.84	
103.86				172.86	
103.88				172.88	
103.90				172.90	
103.92				172.92	
103.94				172.94	
103.96				172.96	
103.98				172.98	
104.00				173.00	
104.02				173.02	
104.04				173.04	
104.06				173.06	
104.08				173.08	
104.10				173.10	
104.12				173.12	
104.14				173.14	
104.16				173.16	
104.18				173.18	
104.20				173.20	
104.22				173.22	
104.24				173.24	
104.26				173.26	
104.28				173.28	
104.30				173.30	
104.32				173.32	
104.34				173.34	
104.36				173.36	
104.38				173.38	
104.40				173.40	
104.42				173.42	
104.44				173.44	
104.46				173.46	
104.48				173.48	
104.50				173.50	
104.52				173.52	
104.54				173.54	
104.56				173.56	
104.58				173.58	
104.60				173.60	
104.62				173.62	
104.64				173.64	
104.66				173.66	
104.68				173.68	
104.70				173.70	
104.72				173.72	
104.74				173.74	
104.76				173.76	
104.78				173.78	
104.80				173.80	
104.82				173.82	
104.84				173.84	
104.86				173.86	
104.88				173.88	
104.90				173.90	
104.92				173.92	
104.94				173.94	
104.96				173.96	
104.98				173.98	
105.00				174.00	
105.02				174.02	
105.04				174.04	
105.06				174.06	
105.08				174.08	
105.10				174.10	
105.12				174.12	
105.14				174.14	
105.16				174.16	
105.18				174.18	
105.20				174.20	
105.22				174.22	
105.24				174.24	
105.26				174.26	
105.28				174.28	
105.30				174.30	</td

**IMPACT PREDICTIONS USING  
WIND WEIGHTING FACTOR  
METHOD**

This is a report outlining the basic method used at Eglin for making impact predictions for high altitude research rockets.

The data contained in this report, including conclusions and recommendations, are tentative and should not be construed to represent final conclusions, recommendations, or decisions of the Armament Division.

**Armament Division  
Air Force Systems Command  
United States Air Force  
Eglin Air Force Base, Florida**

## INTRODUCTION

At Eglin Air Force Base, impact predictions which account for the effect of winds on the vehicle trajectories are made using the wind weighting factor method. This report describes the method and gives a sample impact prediction. Most of the predictions for actual vehicle launches are accomplished on a small digital computer. The method is basically the same whether done on the computer or by hand as outlined herein.

## DISCUSSION

The method used for impact prediction is the wind weighting technique. In essence, the impact displacements caused by the wind over various altitude increments give the impact point.

The effect of unit wind on the displacement of the impact point varies with magnitude of wind, direction of wind, and launch elevation angle. To retain the simple method and predictions with acceptable accuracy we use a 10-knot headwind and compute for the planned launch angle. This 10 knots is approximately a weighted average for this area.

Using the 10 knots of wind as a standard, trajectories are computed using six-degree-of-freedom equations with the winds terminated at altitudes of desired interest. The range of interest depends upon the altitude achieved by the vehicle during burning of each stage. The Nike-Cajun as given in the Nike-Cajun (Project 5631W1) Dispersion and Launch Data, dated 17 August 1962, is being used to illustrate the impact prediction method. Trajectories with 10-knot headwinds (from the south) terminated at 250, 500, 750, 1000, 1250, 1500, 1750, 2000, 3000, 4000, 5000, 10000, 2000, 28000, 35000, 40000, and 55000 were used. The launch azimuth and elevation angles will be the same for all of the above trajectories. Using the same azimuth and elevation angles a standard (nonperturbed) trajectory is computed.

The vehicles launched by this Center will be in a southerly direction and for this reason all of the azimuth angles will be for a due south launch.

After computing the trajectories a listing of impact points is made. The listing consists of range from the launch site and deflection from the launch azimuth for each of the trajectories. The fact that a due south launch is being used and coriolis is computed and printed out gives a deflection to the west. Taking the listed ranges ( $X_s$ ) for each wind altitude termination point for which a trajectory was computed and subtracting the range ( $X_s$ ) of the standard (nonperturbed) trajectory, from this gives the effect of the wind over this wind altitude. The same procedure is used in computing the wind effect on the deflection. Taking the square root of the sums of the squares gives the total deviation from the standard (nonperturbed) trajectory. Dividing this result by the constant windspeed used to compute the trajectories gives the deviation from the standard trajectory for 1 knot of wind. This result is then normalized to one and plotted on a graph. The rail length of the launcher is 17.5 feet, therefore, the wind weighting curves, in the Nike-Cajun (Project 5631W1) Dispersion Report, begin at 17.5 feet.

Example: Stage II  
 Azimuth =  $0^{\circ}$  CW From South      40 lb. Payload  
 Elevation =  $85^{\circ}$   
 10 Knot Constant Wind from the south  
 NM is Nautical Miles

WIND ALTITUDE (WA) TERMINATION	RANGE (X)	DEPLECTION	$(X_w - X_s)$	$(D_w - D_s)$	TOTAL DEFLECTION DIVIDED BY WINDSPEED USED	WIND FACTOR
					$\frac{\sqrt{(X_w - X_s)^2 + (D_w - D_s)^2}}{10}$	
(FT)	(NM) ( $X_s$ )	(NM) ( $D_s$ )	(NM)	(NM)	(NM/KN)	
0	39.667	3.901				
	( $X_w$ )	( $D_w$ )				
250	46.421	3.954	6.754	.050	.675	.423
500	46.513	3.969	8.846	.065	.885	.554
750	49.759	3.979	10.092	.075	1.009	.632
1000	50.653	3.985	10.986	.081	1.099	.688
1250	51.228	3.989	11.561	.085	1.156	.724
1500	51.675	3.993	12.008	.089	1.201	.752
1750	52.026	3.995	12.359	.091	1.236	.774
2000	52.298	3.997	12.631	.093	1.263	.791
3000	53.064	4.003	13.397	.099	1.340	.839
4000	53.415	4.006	13.748	.102	1.375	.861
5000	53.607	4.007	13.940	.103	1.394	.873
10000	53.575	4.007	13.908	.103	1.391	.871
20000	53.463	4.006	13.796	.102	1.380	.864
28000	53.368	4.005	13.701	.101	1.370	.855
35000	53.192	4.004	13.525	.100	1.353	.847
40000	53.080	4.003	13.413	.099	1.341	.840
45000	53.016	4.003	13.349	.099	1.335	.836
50000	54.645	4.015	14.978	.111	1.498	.938
55000	55.635	4.022	15.968	.118	1.597	1.000

### STAGE I

	$(X_s)$ (FT)	$(D_s)$ (FT)	$(X_w - X_s)$ (FT)	$(D_w - D_s)$ (FT)	$\frac{\sqrt{(X_w - X_s)^2 + (D_w - D_s)^2}}{10}$ (FT/KN)	
	( $X_w$ ) (FT)	( $D_w$ ) (FT)				
0	4852	82				
	( $X_w$ )	( $D_w$ )				
250	5807	82	955	0	95.5	.478
500	6182	82	1330	0	133.0	.666
750	6350	81	1498	1	149.8	.751
1000	6438	82	1586	0	158.6	.795
1250	6531	81	1679	1	167.9	.841
1500	6602	81	1750	1	175.0	.877
1750	6625	82	1773	0	177.3	.888
2000	6675	82	1823	0	182.3	.913
-200	6789	82	1937	0	193.7	.970

WIND ALTITUDE (WA) TERMINATION	RANGE (X) (X <sub>w</sub> ) (FT)	DEFLECTION (D <sub>s</sub> ) (FT)	(X <sub>w</sub> -X <sub>s</sub> ) (FT)	(D <sub>w</sub> -D <sub>s</sub> ) (FT)	$\sqrt{(X_w-X_s)^2 + (D_w-D_s)^2}$ 10 (FT/KN)	WIND FACTOR
4000	6842	82	1996	0	199.6	.998
4250	6852	82	2000	0	200.0	1.000
5000	6820	82	1968	0	196.8	.986
10000	6634	81	1782	1	178.2	.893
20000	6124	81	1272	1	127.2	.637
28000	5734	80	882	2	88.2	.442
35000	5734	80	882	2	88.2	.442

The unit wind effect is .200 feet per knot of wind for the first stage and 1.60 nautical miles per knot of wind for the second stage. The majority of launches at Eglin's Gulf Test Range are near vertical launches and for this reason we can assume that the unit wind effect for a west wind on a vehicle launched south is the same as for a south wind.

More accuracy is achieved by taking the wind factors over smaller altitude increments than used in plotting the wind factor graph. These may now be read directly from the graph in the Nike-Jajun (Project 5631W) Dispersion and Launch Data report. Altitude intervals used are determined by the average rise rate of the weather balloon.

Example:  
STAGE II

WIND ALTITUDE (FT)	WIND FACTOR	WIND FACTOR OVER EACH ALTITUDE INCREMENT (f <sub>tn</sub> )
17.5	0	0
290	.451	.451
550	.571	.120
830	.648	.077
1138	.706	.058
1380	.738	.032
1660	.762	.024
1920	.786	.024
2178	.794	.008
2430	.813	.019
2680	.822	.009
2930	.835	.013
3185	.840	.005
4176	.862	.022
5151	.873	.011
6110	.873	.000

WIND ALTITUDE (FT)	WIND FACTOR	WIND FACTOR OVER EACH ALTITUDE INCREMENT (f <sub>tn</sub> )
7053	.873	.000
8905	.873	.000
9815	.871	-.002
15000	.867	-.004
20000	.862	-.005
25000	.858	-.004
30000	.852	-.006
35000	.847	-.005
40000	.841	-.006
45000	.837	-.004
50000	.936	.099
55000	1.000	.064

### STAGE I

WIND ALTITUDE (FT)	WIND FACTOR	WIND FACTOR OVER EACH ALTITUDE INCREMENT (f <sub>tn</sub> )
17.5	0	C
290	.497	.497
550	.680	.183
830	.740	.060
1138	.804	.064
1380	.844	.040
1660	.869	.025
1920	.910	.041
2178	.932	.022
2430	.948	.016
2680	.963	.015
2930	.975	.012
3185	.982	.007
4176	1.000	.018
5151	.992	-.008
6110	.977	-.015
7053	.960	-.017
7979	.946	-.014
8905	.927	-.019
9815	.908	-.019
15000	.784	-.124
20000	.637	-.147
25000	.540	-.097
30000	.442	-.098

The wind deflection due to the south component of a wind profile:

$$D_{wxt} = \sum_{n=j}^k [S_{xn} f_{tn}] [U_{wx}]$$

where:

$D_{wxt}$  = Total wind deflection.

$S_{nx}$  = Component of the wind from the south at altitude n.

$f_{tn}$  = Fractional wind factor over altitude intervals n.

$U_{wx}$  = Unit wind effect.

j = First altitude listed in the wind profile.

k = Last altitude listed in the wind profile.

The wind deflection due to the west components of the wind profile:

$$D_{wyd} = \sum_{n=j}^k [S_{yn} f_{tn}] U_{wy}$$

All quantities are defined above except here they refer to the west components. The total deflection from the launch site is then given by:

$$D_x = D_{wxt} + D_{wyd}$$

$$D_y = D_{wyd} + D_{nw}$$

where  $D_{nw}$  and  $D_{ny}$  = the no wind x and y impact points.

The deflection from the no wind impact point may be calculated for any wind profile with the information now available. For purposes of illustration we will use the wind profile of the Nike-Cajun launched here on 28 August 1962. The launcher settings for this launch were azimuth  $10^\circ$  CW from south with an elevation setting of  $86.5^\circ$ .

ALTITUDE (FT)	SPEED ( $S_n$ ) (KN)	DIRECTION ( $A_z$ ) (CW FROM NORTH)
290	13.7	172.1
550	15.2	161.8
830	16.9	157.3
1138	18.0	148.8
1380	14.6	134.6
1660	12.1	123.5
1920	13.5	116.0
2178	12.7	104.2
2430	9.9	98.0
2680	10.2	80.8

ALTITUDE (FT)	SPEED ( $s_n$ ) (KN)	DIRECTION ( $A_z$ ) (CW FROM NORTH)
2930	10.6	75.7
3185	10.6	83.9
4176	12.1	74.3
5151	12.3	65.3
6110	10.8	62.4
7053	10.0	50.5
7979	10.1	35.0
8905	7.6	25.0
9815	4.5	13.3
15000	10.0	310.0
20000	10.0	310.0
25000	10.0	310.0
30000	12.0	300.0
35000	15.0	30.0
40000	15.0	20.0
45000	15.0	30.0
50000	13.0	40.0
55000	12.0	90.0

#### STAGE I & II

WIND ALTITUDE (FT)	COMPONENT OF WIND FROM SOUTH $s_{xn} = s_n \cos(A_z + 180)$	COMPONENT OF WIND FROM WEST $s_{yn} = s_n \sin(A_z + 180)$
290	13.6	-1.8
550	14.4	-4.7
830	15.6	-6.5
1138	15.4	-9.3
1380	10.2	-10.4
1660	6.7	-10.1
1920	5.9	-12.1
2178	3.1	-12.3
2430	1.4	-9.8
2680	-1.6	-10.1
2930	-2.6	-10.5
3185	-1.1	-10.5
4176	-3.3	-11.6
5151	-5.1	-11.2
6110	-5.0	-9.6
7053	-6.3	-7.7
7979	-7.1	-5.8
8905	-6.9	-3.2
9815	-4.4	-1.0
15000	-6.4	7.7

WIND ALTITUDE (FT)	COMPONENT OF WIND FROM SOUTH $S_{xn} = S_n \cos(A_z + 180)$	COMPONENT OF WIND FROM WEST $S_{yn} = S_n \sin(A_z + 180)$
20000	-6.4	7.7
25000	-6.4	7.7
30000	-7.7	9.2
35000	-13.0	-7.5
40000	-14.1	-5.1
45000	-13.0	-7.5
50000	-10.0	-8.4
55000	0	-12.0

The deflections from the no wind impact points are given by:

#### Stage I

$$D_{wxt} = \left[ \begin{matrix} (13.6)(.497) \\ [200] \end{matrix} \right] \left[ \begin{matrix} [200] \\ [(-7.7)(.098)] \end{matrix} \right] \left[ \begin{matrix} [(15.2)(.183)] \\ [200] \end{matrix} \right]$$

$$D_{wxt} = 3125 \text{ feet}$$

$$D_{wyt} = \left[ \begin{matrix} (-1.8)(.497) \\ [200] \end{matrix} \right] \left[ \begin{matrix} [200] \\ [(9.2)(.098)] \end{matrix} \right] \left[ \begin{matrix} [(-4.7)(.183)] \\ [200] \end{matrix} \right]$$

$$D_{wyt} = 1584 \text{ feet}$$

#### Stage II

$$D_{wxt} = \left[ \begin{matrix} (13.6)(.451) \\ [(0)(.064)] \end{matrix} \right] \left[ \begin{matrix} [1.6] \\ [1.6] \end{matrix} \right] + \left[ \begin{matrix} [(15.2)(.120)] \\ [1.6] \end{matrix} \right] + \dots$$

$$D_{wxt} = 15.5 \text{ nautical miles}$$

$$D_{wyt} = \left[ \begin{matrix} (-1.8)(.451) \\ [(-12.0)(.064)] \end{matrix} \right] \left[ \begin{matrix} [1.6] \\ [1.6] \end{matrix} \right] + \left[ \begin{matrix} [(-4.7)(.120)] \\ [1.6] \end{matrix} \right] + \dots$$

$$D_{wyt} = -12.3 \text{ nautical miles}$$

The no wind impact points are given as follows:

#### STAGE I

$$\begin{aligned} D_{max} &= 4432 \\ D_{nwy} &= 1051 \end{aligned}$$

#### STAGE II

$$\begin{aligned} D_{max} &= 27.6 \\ D_{nwy} &= 8.3 \end{aligned}$$

From the preceding discussion the total deflection from the launch site is now given as follows:

STAGE I

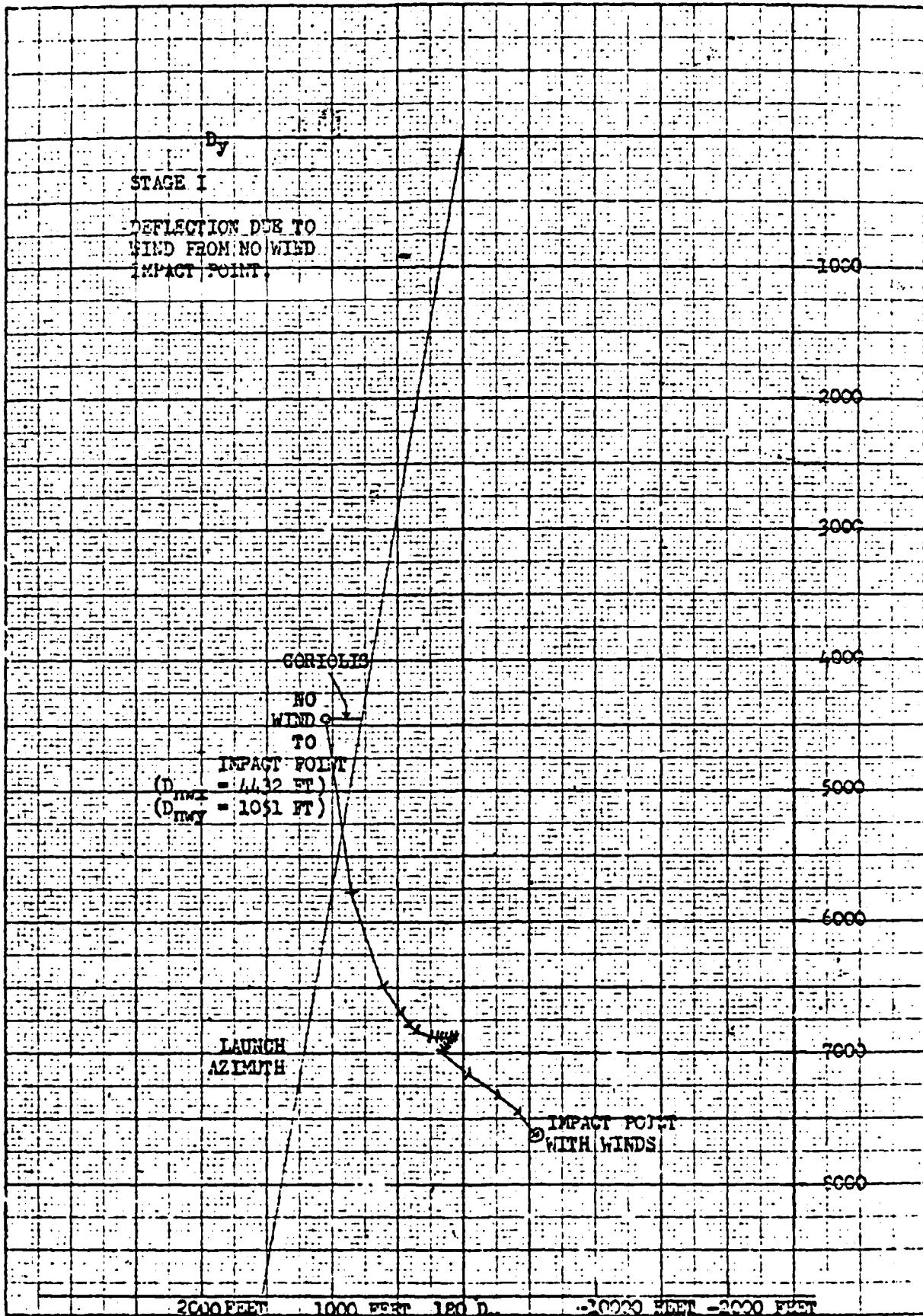
$$\begin{aligned}D_x &= 3125 + 4432 \\D_x &= 7557 \text{ feet} \\D_y &= -1584 + 1051 \\D_y &= 533 \text{ feet}\end{aligned}$$

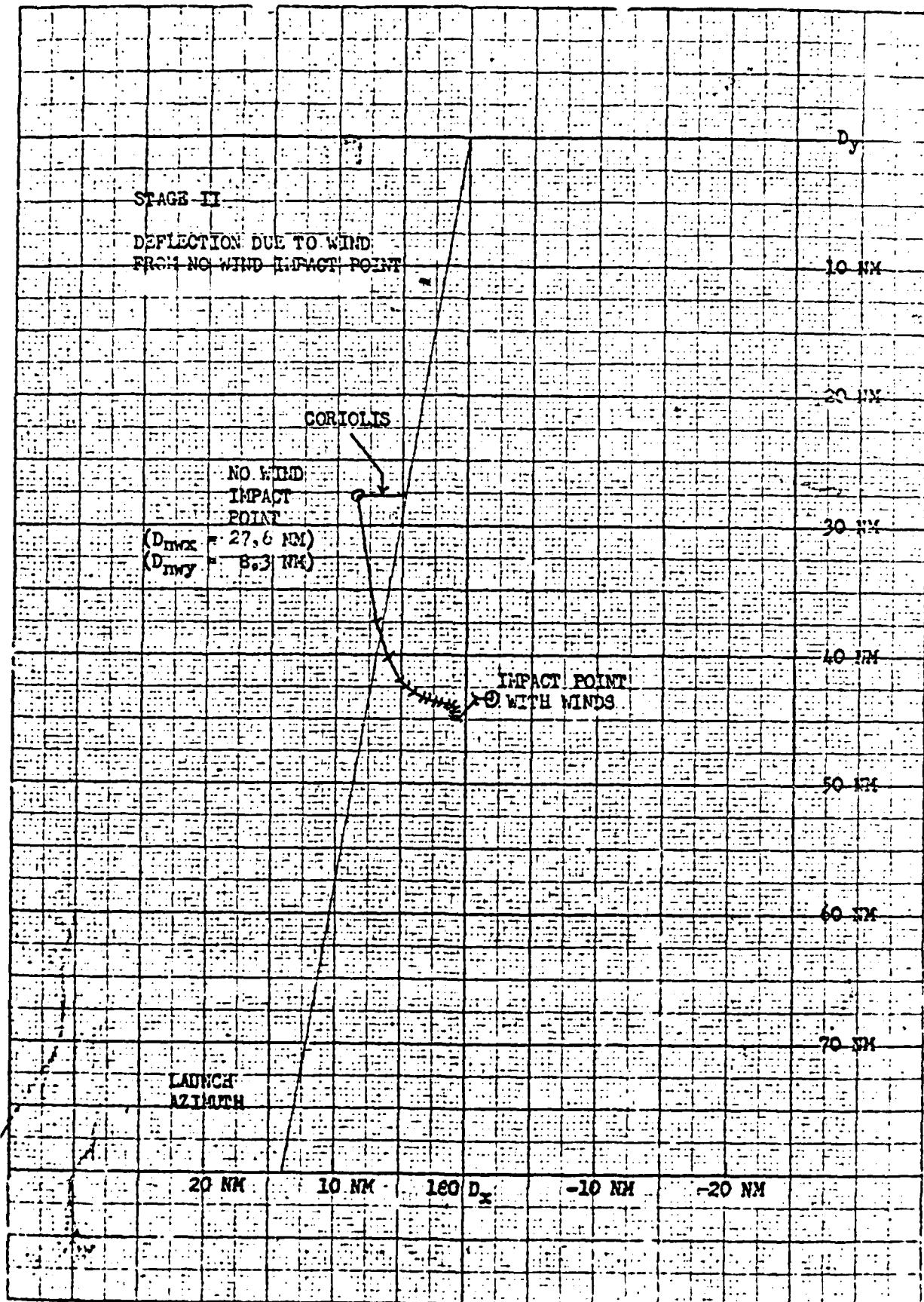
STAGE II

$$\begin{aligned}D_x &= 15.5 + 27.6 \\D_x &= 43.1 \text{ nautical miles} \\D_y &= -12.3 + 8.3 \\D_y &= -4.0\end{aligned}$$

The actual impact of stage II was received from telemetry readings as  $D_x = 39.4$  nautical miles and  $D_y = 8.6$  nautical miles. No impact was recorded for the first stage.

To plot the deflection from the no wind impact point multiply the wind factor for each altitude increment ( $f_{tn}$ ) by the unit wind effect ( $U_w$ ) and then multiply the results of this by the windspeed ( $S_n$ ) for this particular altitude increment  $\left[ (f_{tn})(U_w) \right] \left[ (S_n) \right]$ . This result is then plotted as a vector along the azimuth ( $A_z$ ) given in the wind profile if the result is positive and if the result is negative it is plotted in the opposite direction from the azimuth angle ( $A_g + 180$ ). The sample used previously is included here in plotted form.





Appendix F

NAVAL WEAPONS CENTER (NWC)  
ROCKET SAFETY

SAFETY CRITERIA  
FOR  
INERT AERODYNAMIC PROJECTILES

GENERAL

The hazard footprints for aerodynamic projectiles that are test launched from a variety of platforms shall be determined by a combination of historical and simulated data that is available from the manufacturer, designer and/or project director. In addition to the generalized data inputs, specialized criteria are applied relative to physical characteristics, launch approach and test range limits.

SPECIALIZED

(1) Rockets (Ground Launched)

The hazard area for firings from rocket launchers is defined as the area included by a circle of 1500 feet radius with the launcher at the center, plus the area bounded by an arc drawn at a distance equal to 125 percent of the maximum range of the weapon, regardless of the QE of actual firing, and two lines tangent of the circle extending outward to an angle of 200 mils from the azimuth of firing.

(2) Missiles (Ground Launched)

The area included by a circle of 1500 feet radius, with the launcher as the center, is an immediate danger area during launch of any missile.

Two lines tangent to the 1500 feet radius circle and extending outward from the guided missile line-of-fire at an angle of 400 mils. The 400-mil angle can be reduced to 200 mils for certain missile and launch characteristics relative to range topography.

The missile launch elevation angle is generally limited to 60 degrees. Higher elevations are permitted, but only after consideration on individual basis.

After launch, missile flight deviations may be permitted within the area bounded by a line passing through the launcher and normal to guide missile line-of-fire and boundaries of test range.

(3) Large Gun-Launched Projectiles

For smoke puff or inert nonfragmenting projectiles, the area forward of gun bounded by two lines parallel to lines of 40-mil deflection in each direction but displaced 500 feet further away from axis of fire. The downrange end of this area is closed by an arc drawn at a distance equal to 125 percent to the maximum range of a round, regardless of the quadrant elevation (QE) of actual firing.

**Appendix G**

**NASA WALLOPS FLIGHT CENTER ROCKET SAFETY**

**(EXCERPTS FROM WALLOPS FLIGHT CENTER MANAGEMENT INSTRUCTION,  
RANGE USERS SAFETY HANDBOOK, AND  
DATA FORMATS FOR VEHICLE AND PAYLOAD)**



National  
Aeronautics and  
Space  
Administration

WMI 1771.1 Rev.1

July 3, 1978

DATE

## WALLOPS FLIGHT CENTER MANAGEMENT INSTRUCTION

SUBJECT: RANGE SAFETY POLICIES AND CRITERIA

- REF : (a) WMI 1700.1  
(b) WMI 1700.2  
(c) NHB 1700.1(VI)

### 1. PURPOSE

This Instruction establishes the range safety policies and criteria for mission operations conducted by Wallops Flight Center (References (a) and (b)).

### 2. SCOPE

This Instruction applies to all mission activities to be conducted by Wallops Flight Center and to all personnel directly or indirectly involved, including contractor and range user personnel.

### 3. DEFINITIONS

See Enclosure A.

### 4. POLICIES AND CRITERIA

Wallops Flight Center will conduct all operations, both ground and flight, with a degree of prudence appropriate for highly hazardous operations and in accordance with sound technology. In this manner, the possibility of injuring personnel, damaging property, or embarrassment to the United States will be minimized. To achieve this objective, two cardinal principles are applied: (1) It is impossible to completely eliminate human error; therefore, safety planning and precautions must be established to cope with the resulting hazards. (2) One preventive safety factor is not sufficient; planning and procedures should provide that a combination of at least two extremely unlikely events must occur to cause an accident.

Following are the specific policies and criteria which have been promulgated in support of this general policy. For any missions where these policies cannot be met, the risk will be analyzed and presented for approval to the Director, Wallops Flight Center in a Safety Analysis Report (Reference (c)).

- (j) Area clearance: Times, roadblock locations, and responsibility.
- (k) R-f energy restrictions: Periods when r-f silence is required by various operations.
- (l) Special procedures: Abort, recovery, possible unsafe conditions, and required warning systems.
- (m) Special tests conducted: R-f simulations, circuit checks, and simulated flights.

b. Flight Safety

The flight safety goal is to contain the flight of all vehicles and to preclude an impact which might endanger human life, cause damage to property, or result in embarrassment to NASA or the U. S. Government. Although the risk of such an impact can never be eliminated completely, flight should be planned carefully to minimize the risks involved while enhancing the probability for attaining the mission objectives.

(1) Impact Criteria

All flights will be planned in accordance with impact agreements and conducted so that the planned impact or reentry of any part of the launch vehicle over any land mass, sea, or airspace does not produce a casualty expectancy greater than  $10^{-7}$  and an impact probability on private or public property which might cause damage greater than  $10^{-3}$  unless a Safety Analysis Report is prepared and approved, or it can be proven that:

- (a) the reentering vehicle will be completely consumed by aerodynamic heating, or
- (b) the momentum of solid pieces of the reentering vehicles (such as balloons, parachutes, etc.) will be low enough to preclude injury or damage, or
- (c) formal Government or private agreements allow the use of the land mass for impact or reentry.

(2) Overflight Criteria

No vehicle may overfly a populated area in violation of previous Governmental or private agreements and unless the vehicle is in orbit or the probability of an overflight failure does not violate impact criteria or unless approved in a Safety Analysis Report.

(3) Flight Termination Criteria

Wallops' basic flight safety policy requires a flight termination system in every stage of a launch vehicle unless it is shown that the flight is inherently safe, which is determined by probability estimates based on known system errors and the following set of qualifying conditions:

- (a) The launch vehicle does not contain a control or guidance system and is incapable of assuming any trim angle that produces sufficient lift for the vehicle to violate the planned impact area.
- (b) The acceleration at lift-off must be greater than 3.5 g's and/or there must be a high degree of confidence that the vehicle can be wind-corrected accurately..
- (c) For new or modified vehicles, the proposed launch elevation angle must not exceed 80°, and the proposed azimuth must be such that the geographical advantages of Wallops' impact area are recognized. If vehicle reliability has been established, the 80° launch elevation angle limit may be exceeded provided that the probability of failure does not violate flight safety limits and the impact criteria are not violated.
- (d) The launch vehicle must be designed using state-of-the-art techniques that have been proven highly reliable by flight tests or otherwise proven flightworthy.

If a launch vehicle cannot meet the above set of conditions, a flight termination system must be employed whereby thrust may be terminated, stage ignition prevented or delayed, or other means employed to insure that the impact and overflight criteria are not exceeded.

(4) Flight Termination System Design Requirements

A preliminary design of a vehicle flight termination system must be submitted to the Ground and Flight Safety Section by the range user for analysis and approval. (In some cases, the Ground and Flight Safety Section may prepare this design.) The design requires close coordination between the range user and the Ground and Flight Safety Section. The flight termination system design requirements will be the same as II-B (Ground Safety Criteria), in addition to the following:

- (a) Use of components that are specified and tested to exceed the environmental flight conditions to which the system will be subjected.

- (b) The specifications for the command receiver/decoder must be the greater of: (1) the expected vehicle environment or (2) those specifications defined in Enclosure B. The command receiver/decoder must be 100% qualified at its specifications.
  - (c) A dual system is required unless approval for a single system is given by the Head, Ground and Flight Safety Section. For a dual system, the command receiver antenna system and the resulting antenna patterns shall be such that at least one of the receivers remains captured regardless of any conceivable vehicle maneuver, and both receivers remain captured for normal trajectories and vehicle attitudes.
  - (d) The electrical system for flight termination systems will be kept both physically and electrically isolated from other vehicle instrumentation circuits. The system will not use common batteries, wiring, or electrical switches with any other vehicle or payload system. Whenever possible, remotely activated batteries will be employed.
  - (e) The electrical interface between the command receivers and all required pyrotechnic devices shall be designed so that a single receiver is capable of actuating all pyrotechnic bridgewires.
  - (f) For destruct systems, safe-arm units are necessary and vehicle access must be provided for the electrical connection and initial arming of the units as near to launch as possible.
  - (g) Final arming of destruct safe-arm units will be performed remotely prior to launch.
  - (h) Checkout procedures for flight termination systems will be designed for ease and completeness with maximum safety to personnel and facilities.
  - (i) All components of the flight termination system must be located and mounted in the vehicle so as to provide acceptable security against system failure from all conceivable vehicle malfunctions.
  - (j) The system will be designed so that a single order failure shall not cause failure or actuate the pyrotechnic items.
- (5) Flight Planning Criteria

Launch vehicle flight safety is generally associated with the containment of spent stages, hardware, and payload components within planned impact areas. Each flight is unique, since the

entire set of variables (vehicle aerodynamic/ballistic capabilities; azimuth and elevation angles; wind, air, and sea traffic, and proposed impact areas) are never duplicated. Therefore, vehicle design reliability, performance, and error predictions for each flight case will be analyzed by the Ground and Flight Safety Section personnel to ascertain the flight-worthiness of the launch vehicle and to develop plans which assure compliance with established flight safety criteria.

(6) Range Clearance Criteria

Wallop Flight Center will coordinate its operations with the FAA, U. S. Navy, and other organizations as required to clear impact areas. The impact hazard area for each rocket is defined and all flight safety impact criteria must be satisfied before launching is allowed. When necessary, Wallop Flight Center will require NOTAMS and HYDROLANTS to be issued prior to the launch date. No vehicle will be launched without prior clearance.

(7) Flight Safety Plan

A Flight Safety Plan is prepared by Ground and Flight Safety prior to any vehicle launching. This plan describes the quantitative and qualitative aspects of the proposed vehicle flight. The data and requirements are as follows:

(a) Project data:

The vehicle name and number, firing time, Range User project data and personnel, Wallop Flight Center Project Engineer, Test Director, and Range Safety Officer.

(b) Vehicle description:

Number of stages, type of motor, thrust and burning time for each, stage separation method, type of nose cone or heat shield, and any other special characteristics.

(c) Guidance and control system:

Gyro system, fins, vanes, jets, and spin-stabilization for each stage.

(d) Flight termination:

Destruct or hold-fire capabilities for each stage; how command is transmitted and received; a listing of the events, combinations of events, or losses of data which will cause the Flight Safety Officer to terminate the flight.

(e) Payload:

A brief description of the type of payload and purpose of the experiment.

(f) Instrumentation support requirements:

Required radar, beacon, optical, telemetry, and camera coverage.

(g) Flight parameters for each stage:

Elevation and azimuth angles; range; apogee; permissible elevation, azimuth, impact, and velocity limits; ignition and burnout velocity, time, and "g's"; impact time, coordinates, and dispersion area.

(h) Weather limitations:

Ceiling, visibility, wind, temperature, and precipitation factors.

(i) Range Clearance:

A discussion of what coordination has been effected to ensure clearance of the flight hazard spaces of all stages, including impact areas, and what surveillance of the areas will be maintained prior to and during the flight period.

(j) Trajectories:

A discussion of the predicted flight of each stage of the vehicle, and the consequences of all predictable vehicle malfunctions.

(8) Off-Range Operations Criteria

The Wallops Flight Center flight safety policies and criteria are applicable to all off-range operations performed by WFC personnel. Missions performed at other ranges will comply with their policies; however, flight safety limits established by the Ground and Flight Safety Section for such missions will also not be exceeded.

5. RESPONSIBILITIES

a. Directorate Directors and their respective line management organizations are responsible for:

- (1) The safety of personnel, facilities, and the public; and for assuring compliance with safety policies of the Center's Director.

WHB 1771.1  
March 1979

# Range Users Safety Handbook



National Aeronautics and  
Space Administration

**Wallops Flight Center**  
Wallops Island, Virginia 23337  
AC 804 824-3411

- 2 Grounding - A grounding system exists in all operational areas on Wallops Island. It is the responsibility of range users that their system is properly grounded to the existing system.
- (e) Emergency - Wallops Flight Center has established emergency procedures to evacuate personnel as required in the event of handfire, misfire, abort, and recovery. Range users are responsible for identifying personnel as required by the Wallops Flight Center to participate in any emergency or recovery team.

## 5. FLIGHT SAFETY

### a. General

The flight safety goals are to contain the flight of all vehicles and to preclude an impact which might endanger human life, cause damage to property, or result in embarrassment to NASA or the U. S. Government. Although the risk of such an impact can never be eliminated completely, the flight should be planned carefully to minimize the risks involved while enhancing the probability for attaining the mission objectives.

### b. Operational Procedures

#### (1) Vehicle Without Flight Termination

##### (a) Wind Weighting

All unguided vehicles launched from the Wallops Flight Center will be required to be wind compensated. To accomplish this, range users must furnish Wallops Flight Center with data consistent with currently used wind compensation methods.

##### (b) Shipping

- 1 All impacts within the Virginia Capes operating areas (VACAPES) require clearance prior to launch. All impacts outside VACAPES require clearance with the FAA. Wallops Flight Center is responsible for obtaining this clearance and to do this, range users are required to provide the predicted impact related dispersion data for each re-entering body.
- 2 No launch will be conducted in which the ship-hit probability exceeds 1 in 100,000 or an aircraft-hit probability exceeds 1 in 10 million.

(c) Launch Limitations

- 1 The normal launch elevation and azimuth limitations are:
  - a Nominal elevation not to exceed 80° and nominal azimuth between 90° and 150°.
  - b Deviations from above are possible so long as the impact and overflight criteria are met.
- 2 Launch wind limitations will be established for each vehicle and will be published in the flight safety plan.
- 3 Launch limitations for new vehicle systems may be more stringent than above.

(2) Vehicle With Flight Termination

- (a) Shipping and impact probability are the same as in (1)(b) above.

(b) Prelaunch Checks

- 1 Command receiver - Laboratory checks will be performed to verify the minimum command receiver specifications as defined in Enclosure B of Reference (a).
- 2 Flight Termination System - Wallops Flight Center requires that a functional test be used to verify the flight termination system. Wallops requires that a command drop out test be performed as the last functional test in verifying the flight termination system.

(c) Launch Limitations

- 1 Azimuth and elevation limits will be established to implement the impact and overflight criteria outlined in Reference (a). To implement this, Wallops Flight Center requires range users to provide vehicle data as outlined in Appendix A.
- 2 Wallops Flight Center requires that two independent radar systems provide real time data during launch. To meet this requirement, either one of the following will be accepted:
  - a Two skin tracking radars.
  - b One skin and one beacon tracking radar.
  - c Two beacon tracking radars.

If method a or b is used, Wallops Flight Center will impose a ceiling limitation to ensure visibility until the skin tracking radar has adequate time to lock its automatic tracking systems.

- 3 Real-time Instantaneous Impact Prediction (IIP) and telemetry data - Range users will supply personnel as required for real-time data evaluations.

(3) Additional Range Users Responsibilities

- (a) Provide data to the Ground and Flight Safety Section for safety analysis. (See appendix A.)
- (b) Determine the minimum requirements for launch. If a range user determines that his/her requirements are more stringent than those determined by the Ground and Flight Safety Section, coordination will be required between Section and range user personnel.
- (c) As required by the Ground and Flight Safety Section, participation in real-time data evaluation for flight termination and/or control missions.
- (d) Participate in discussions with Ground and Flight Safety Section personnel to familiarize safety personnel with vehicle performance characteristics.

- 9 Range user personnel monitoring devices and methods of use (portable survey instruments, personnel dosimeters, film badges, procedures, etc.).
- 10 Location of radioactive source on research vehicle.
- 11 Range user's person who shall have responsibility at the Range.
- 12 Prior to operations at this Center, a record of exposure of each individual who will be exposed at the Range. This should include total exposure, last exposure date, etc.
- 13 A detailed breakdown of estimated time of source exposure during all build-up, test, and launch operations.
- 14 Procedure for handling and use of external sources during all times exposed.
- 15 All calibration procedures involving the use of exposed radioactive sources.

c. Performance and Flight Worthiness Data

(1) Normal Flight Trajectory

A computer printout providing a time history, including the following parameters may be required. (Round or oblate rotating earth trajectory is required for long-range missions.)

- (a) Weight
- (b) Thrust
- (c) Altitude
- (d) Ground range (great circle)
- (e) Slant range
- (f) Velocity (inertial and earth relative)
- (g) Mach number
- (h) Dynamic pressure
- (i) Elevation flight path angle (inertial and earth relative)
- (j) Azimuth flight path angle (inertial and earth relative)

(k) Position (latitude and longitude)

- (l) Acceleration, and if a six degree of freedom trajectory was performed, submit a copy; for some missions, this trajectory will be mandatory.

For vehicles with flight termination systems, the following additional parameters are required with reference to an x,y,z orthogonal coordinate system with the x, y plane tangent to the spheriod at the launch site and the x-axis in the direction of the launch azimuth.

(m) x, y, z in feet

(n) Velocity components  $\dot{x}$ ,  $\dot{y}$ ,  $\dot{z}$  in feet per second

(o) Slant range ( $R = (x^2 + y^2 + z^2)^{1/2}$ ) in feet

(p) Elevation flight path angle ( $\tan^{-1} Z/R$ ) in degrees

(q) Total velocity ( $V = (\dot{x}^2 + \dot{y}^2 + \dot{z}^2)^{1/2}$ ) in feet per second

The trajectory for each expended stage is required from separation to impact. State method used in trajectory calculations and provide definition of all parameters included in the trajectory study. In addition to the aforementioned tabulated date, the following plotted data are required:

(a) Profile of trajectory - Altitude versus range. Show planned trajectory indicating pertinent events, such as ignition and burnout of stages, separation, and impact points.

(b) Plan View of Trajectory - Show plan view of trajectory, indicating the launch and trajectory azimuth in degrees from true north. Indicate the impact points of the various stages and maximum probable dispersion pattern for each point. Various significant land masses will be shown in true geographical location. Longitude and latitude lines will be indicated and identified.

(2) Dispersion Data

Give total dispersion data in terms of one, two, and three sigma curves for all impacts. The dispersion analysis should include the following effects (give applied values for each type):

Thrust misalignments, stage-to-stage misalignments, aerodynamic misalignments, uncompensated winds, launcher misalignments, errors in performance prediction, guidance and control system errors.

(3) Vehicle Physical Characteristics

Give a detailed summary of the weights of the major sections and components. Include a plot of estimated vehicle weight versus time from launch to impact. For each stage, give the variation of vehicle weight, center of gravity, and moments of inertia as a function of time. Provide a plot of mass distribution and vehicle's stiffness characteristics (EI). Plot fundamental, second, and third structural frequencies versus time.

(4) Rocket Motors

Describe all rocket motors, starting with the first stage. For each stage, include type of propellant, motor case and nozzle materials, nozzle characteristics, temperature limitations, lengths, diameter, propellant weight, loaded and burnout weights, consumed weight, specific impulse, total impulse, effective burnout time, nozzle expansion ratio, exit area, thrust time history, and any special handling or environmental requirements. Classified ballistic information should be included in a separate appendix.

(5) Vehicle Structural Limitations

Indicate the probability of exceeding the flight allowable vehicle bending moment for various peak wind speeds at several peak wind altitudes. State Q-Alpha (product of dynamic pressure and angle of attack) for allowable or ultimate bending moments and state critical body station for failure.

(6) Aerodynamics

Stability data for all stage combinations, including variations of vehicle lift curve slope, pitch moment curve slope, restoring pitching moment slope, center of pressure, static margin, natural pitching frequency, roll rate, pitch damping coefficient, jet damping coefficient, and drag coefficient as a function of Mach number.

(7) Wind Compensation Method

A wind effect analysis and the methods used for calculation are required.

(8) Guidance and Control System

Give a complete description, including their function, of all guidance and control systems.

(9) Gross Hazards

A gross hazard analysis could be required on critical systems, depending on the specific project. Identification of each hazard, the preventative measures to reduce each hazard, and a risk assessment for those hazards which cannot be eliminated by preventative measures should be included in the gross hazards analysis.

(NOTE - The performance and flight worthiness data requirements listed above are applicable to rockets that have been flown previously from the Wallops Flight Center Range. If the vehicle is a new configuration or the first of its type to be fired from Wallops, than additional supplementary detailed data pertinent to a flight worthiness review may be required. This data requirement would be peculiar to each specific project and could include thermodynamic analysis, stress analysis, aeroelastic and flight loads analysis, launch dynamic analysis, coning analysis, turning rate analysis, etc.)

d. Information Time Schedule

All data requirements for vehicle and payload are the same data that are listed in the Wallops Flight Center vehicle description and payload description documents. Preliminary information must be submitted 90 days before launch and all final test preparation data, 30 days before launch.

FORMAT  
FOR  
VEHICLE DESCRIPTION DOCUMENT

1. ADMINISTRATIVE DATA

1.1 PRIME GOVERNMENT AGENCY

State the agency, division, branch, section, etc.

1.2 SUPPORT AGENCIES

All agencies supporting the mission should be listed.

1.3 PRIME VEHICLE CONTRACTOR

State the name and address of the prime contractor.

1.4 OFFICIAL NASA PROJECT DESIGNATION

State the official NASA project designation.

1.5 OTHER DESIGNATIONS

Other project designations "nicknames," prior nomenclature, etc., should be listed.

1.6 RESPONSIBLE PROJECT PERSONNEL

Give the title, responsibility, name, business and home addresses, and telephone numbers of all responsible project officers.

1.7 CLASSIFICATION LEVELS

List all classified phases of the program and the degree of classification.

2. GENERAL INFORMATION

2.1 LAUNCH OBJECTIVES

Give primary and secondary objectives of the launch, including all experiments not contained in the payload.

2.2 LAUNCH WINDOW

Give the preferred launch time and the allowable period in case of holds. Also state the controlling factors for determination of the launch window and who may authorize deviation.

**2.3**

**TRAJECTORY REQUIREMENTS**

State the type of trajectory required to satisfy test requirements. Give the desired elevation and azimuth at launch, along with all parameters necessary to define the trajectory. These should include altitude, velocity, ground range, slant range, and flight path angle at significant times. For orbital missions, apogee, perigee, and orbital inclination should be included.

**3.**

**TEST VEHICLE DESCRIPTION**

**3.1**

**GENERAL DESCRIPTION**

The general description must include the type of vehicle, number of stages, type of propulsion system, and other general operational features. Six copies of vehicle cutline drawings should be included which give all details necessary for proper assembly of the test vehicle or model. Include all pertinent dimensions and a complete parts list.

**3.2**

**AIRFRAME ASSEMBLIES**

Airframe assemblies are defined as the fins, mounting hardware, base section, transition sections, heat shields, and wiring tunnels. Give structural details of all airframe assemblies, paying particular attention to weights, dimensions, separation systems, materials, methods of jettisoning heat shield, etc.

**3.3**

**SYSTEMS**

**3.3.1**

**GUIDANCE AND CONTROL SYSTEMS**

Give a general description of the integrated guidance and control system.

**3.3.2**

**GUIDANCE SYSTEM**

Give a complete description of each major component of the guidance system and its operation.

**3.3.3**

**CONTROL SYSTEM**

For each stage of vehicle (including coast periods as well as burning periods), describe the control system completely, including any necessary propellents.

**3.3.4**

**VEHICLE TELEMETRY SYSTEM**

A complete description of the telemetry system, its operation and its instrument sensors should be provided. To be included is the method of providing timing signal, power source and output, battery life, battery charging, handling and replacement, accessibility, prelaunch operation of system, system environment restrictions, and effects of payload operation on booster systems environment. Give the type of antenna system and radiation pattern.

**3.3.5**

**COMMAND SYSTEMS**

Give a complete description of all command systems, such as command destruct system, hold fire, fuel cut off, etc. Include all circuits, method of operation, operating procedure, and precautions. (See section 6.1.1.)

**3.3.6**

**TRANSPONDER AND/CB BEACON SYSTEM**

Describe the transponder and/or beacon system, including transmitter and receiver frequencies, transponder delay time, type of antenna system and radiation pattern. If a CW beacon, give the beacon frequency and power source details.

**3.3.7**

**IGNITION SYSTEM**

Give a complete description of the ignition system, including wiring diagrams, power sources, arming techniques, etc. (See section 6.1.1.)

**4.**

**RANGE USER'S GROUND SUPPORT EQUIPMENT**

State in detail the ground support equipment which will be supplied by the range user. Describe the electromagnetic radiation characteristics of special equipment, including the purpose or function of the equipment, type of emission, average and peak power output, modulation characteristics, antenna description, and expected location of equipment with respect to the test vehicle launch site.

**5.**

**LAUNCHER INFORMATION**

**5.1**

**TYPE OF LAUNCHER**

State the type of launcher required for the vehicle; i.e., mobile, fixed, rail, zero length, etc.

**5.2**

SOURCE OF LAUNCHER

State whether or not it is planned to use the launch facilities available at Wallops Island. If not, give details explaining who will furnish the launcher.

**5.3**

SPECIAL LAUNCHER REQUIREMENTS

State requirements for any necessary modifications to existing launcher, special pad preparation or work platforms. State any other special requirements.

**6.**

SAFETY INFORMATION

**6.1**

HAZARDOUS MATERIALS

**6.1.1**

PYROTECHNIC DETAILS

Six readily distinguishable copies of schematics and wiring diagrams of all pyrotechnic circuits and all other circuits, physically or electrically related to pyrotechnics are required. For each squib, show on the drawings the minimum sure-fire current, maximum no-fire current, recommended firing current, nominal resistance and, if available, the r-f characteristics.

Give a description of the power source, including output, battery life, and details on battery charging. Scale drawings must be supplied for any vehicle having r-f transmitters or beacons showing the location of all pyrotechnic devices in relation to all transmitting antennas. The frequency, range, type of emission, type of radiating antenna and radiated power (both peak and average) shall be shown for each transmitter or beacon. Schematics, drawings, and operational description of pyrotechnic check-out and monitoring equipment, and any other auxiliary equipment must also be supplied. The range must be notified of any changes as it is the range user's responsibility to certify that all drawings are up to date. All pyrotechnic details must be approved by the range.

**6.1.2**

RADIOACTIVE MATERIALS

If radioactive materials are used in the vehicle or any of the checkout procedures, the information in sections 6.1.2.1 and 6.1.2.2 must be supplied.

**6.1.5      OTHER HAZARDOUS MATERIALS**

Give technical details and precautions for any other hazardous materials included in vehicle.

**6.2      OTHER ELECTRICAL DETAILS**

**6.2.1      VEHICLE SCHEMATICS AND CIRCUIT DRAWING**

**6.2.1.1      TELEMETRY AND EXPERIMENT DIAGRAMS**

Give telemetry and experiment block diagrams. Circuit drawings are required if the telemetry or experiment circuits are related to pyrotechnics.

**6.2.1.2      UMBILICAL CIRCUITS**

Connector wiring should be tabulated by pin assignment, function, wire size, connector description, and location.

**7.      PERFORMANCE AND FLIGHT WORTHINESS DATA REQUIREMENTS**

**7.1      NOMINAL FLIGHT TRAJECTORY**

A computer printout providing a time history, including the following parameters is required: (Round or oblate rotating earth trajectory is required for long range missions.)

- (a) Weight
- (b) Thrust
- (c) Altitude
- (d) Ground Range (Great Circle)
- (e) Slant Range
- (f) Velocity (Inertial and Earth relative)
- (g) Mach Number
- (h) Dynamic Pressure
- (i) Elevation flight path angle (Inertial and Earth relative)
- (j) Azimuth flight path angle (Inertial and Earth relative)
- (k) Position - Latitude and Longitude
- (l) Acceleration
- (m) If a six-degree-of-freedom trajectory was performed, submit a copy. For some missions this trajectory will be mandatory.

For vehicles with flight termination systems, the following additional parameters are required with reference to an x, y, z orthogonal coordinate system with the x, y-plane

tangent to the spheroid at the launch site and the x-axis in the direction of the launch azimuth.

- (n) x, y, z in feet
- (o) Velocity components  $\dot{x}$ ,  $\dot{y}$ ,  $\dot{z}$  in feet per second
- (p) Range,  $[R = \sqrt{x^2 + y^2 + z^2}]^{1/2}$  in feet
- (q) Elevation flight path angle ( $\tan^{-1} \frac{\dot{z}}{R}$ ) in degrees
- (r) Total velocity  $[V = \sqrt{\dot{x}^2 + \dot{y}^2 + \dot{z}^2}]^{1/2}$  in feet per second

The trajectory for each expended stage is required from separation to impact. State method used in trajectory calculations and provide definition of all parameters included in the trajectory study. In addition to the aforementioned tabulated data, the following plotted data are required:

(a) Profile of Trajectory - Altitude versus Range

Show planned trajectory indicating pertinent events, such as ignition and burnout of stages, separation and impact points, etc.

(b) Plan View of Trajectory

Show plan view of trajectory, indicating the launch and trajectory azimuth in degrees from true north. Indicate the impact points of the various stages and maximum probable dispersion pattern for each point. Various significant land masses will be shown in true geographical location. Longitude and latitude lines will be indicated and identified.

## 7.2

### DISPERSION DATA

Give total dispersion data in terms of one, two, and three sigma curves for all impacts. The dispersion analysis should include the following effects (give applied values for each type):

- (a) Effects of thrust misalignments
- (b) Effects of stage-to-stage misalignments
- (c) Effects of aerodynamic misalignments
- (d) Effects of uncompensated winds
- (e) Effects of launcher misalignments
- (f) Errors in performance prediction
- (g) Guidance and control system errors

**7.3**

VEHICLE PHYSICAL CHARACTERISTICS

Give a detailed summary of the weights of the major sections and components. Include a plot of estimated vehicle weight versus time from launch to impact. For each stage, give the variation of vehicle weight, center of gravity, and moments of inertia as a function of time. Provide a plot of mass distribution and vehicle's stiffness characteristics (EI). Plot fundamental, second, and third natural structural frequencies versus time.

**7.4**

ROCKET MOTORS

Describe all rocket motors starting with the first stage. For each stage, include type of propellant, motor case and nozzle materials, nozzle characteristics, temperature limitations, lengths, diameter, propellant weight, loaded and burnout weights, consumed weight, specific impulse, total impulse, effective burnout time, nozzle expansion ratio, exit area, thrust time history, and any special handling or environmental requirements. Classified ballistics information should be included in a separate appendix.

**7.5**

VEHICLE STRUCTURAL LIMITATIONS

Indicate the probability of exceeding the flight allowable vehicle bending moment for various peak windspeeds at several peak wind altitudes. State Q-Alpha (product of dynamic pressure and angle of attack), for allowable or ultimate bending moments and state critical body station for failure.

**7.6**

AERODYNAMICS

Stability data for all stage combinations, including variations of vehicle lift curve slope, pitch moment curve slope, restoring pitching moment slope, center of pressure, static margin, natural pitching frequency, roll rate, pitch damping coefficient, jet damping coefficient, and drag coefficient as a function of Mach number.

**7.7**

WIND COMPENSATION METHOD

A wind effect analysis and the methods used for calculation are required.

NOTE:

The performance and flight worthiness data requirement as listed in this section are applicable to rockets that have been previously flown from this range. If the vehicle is a new configuration or the first of its type to be fired from Wallops, then additional supplementary detailed data, pertinent to a flight worthiness review may be required. This data requirement would be peculiar to each specific project and could include thermodynamic analysis, stress analysis, aeroelastic and flight loads analysis, launch dynamic analysis, coning analysis, turning rate analysis, etc.

8. RANGE SUPPORT REQUIREMENTS

8.1 INSTRUMENTATION REQUIREMENTS

8.1.1 RADAR

List trajectory tracking requirements and any special calibration requirements, mode of operation (skin or beacon track), frequency and power of transponder and/or beacon, transponder delay time, data period, and data requirements.

8.1.2 TELEMETRY

For telemetry support, describe the period of operation, type of output desired, and data handling requirements. Also, give in tabular form the number of records and for each record give the frequency, modulation, data time period, number of channels, and paper speed. For each channel, give the filter (cps), channel assignment sub-carrier (KC), commutation channels, range capability of sensor, and full-scale deflection. The following tabular form should be used:

Record No.	X
Frequency	XXX
Modulation	XXX
Data Time Period	XXX

<u>Channel</u>	<u>Filters</u>	<u>Channel Assignment</u>	<u>SCO</u>	<u>Total Deflection</u>	<u>Range</u>
X	XX	XXXX	XX	XX	XX
X	XX	XXXX	XX	XX	XX

**8.1.11    LOCAL R-F FREQUENCIES**

State all local r-f frequencies required for the range user's equipment and their use.

**8.1.12    LOOK ANGLES**

State all look angle requirement.

**8.1.13    ADDITIONAL REQUIREMENTS**

Describe any additional instrumentation requirements.

**8.2    DATA DISPOSITION**

Tabulate the data required from all sources, the number of copies needed, and to whom the data should be sent. Use the following tabular form:

<u>Item No.</u>	<u>Short Description</u>	<u>No. of Copies</u>	<u>When Required</u>	<u>Recipient</u>
X	XXXXX	XX	XXX	XXXX

**8.3    VEHICLE PREPARATION AND LAUNCH**

**8.3.1    RANGE FACILITIES**

State requirements for range vehicle preparation facilities.

**8.3.2    DYNAMIC BALANCE REQUIREMENTS**

For dynamic balancing, the range user is required to furnish the following: center of gravity, the plane locations for the addition of weights, the radius arm from the geometric center for weight placement, dynamic balancing speed, any special environmental conditions, such as temperature, humidity, maximum acceleration and deceleration, and any special balance procedures.

**8.3.3    INERTIA DETERMINATION**

State any requirements for experimentally determining center of gravity and moments of inertia of the vehicle.

WALLOPS STATION  
WALLOPS ISLAND, VIRGINIA

FORMAT

FOR

PAYOUT DESCRIPTION DOCUMENT

This document should be  
submitted to Wallops Station  
not less than 90 days prior  
to launch of any payload.

- 1.** ADMINISTRATIVE DATA
  - 1.1** PRIME GOVERNMENT AGENCY  
State the agency, division, branch, section, etc.
  - 1.2** SUPPORT AGENCIES  
All agencies supporting the mission should be listed.
  - 1.3** PRIME PAYLOAD CONTRACTOR  
State the name and address of the prime contractor.
  - 1.4** OFFICIAL NASA PROJECT DESIGNATION  
State the official NASA project designation.
  - 1.5** OTHER DESIGNATIONS  
Other project designations "nicknames," prior nomenclature, etc., should be listed.
  - 1.6** RESPONSIBLE PROJECT PERSONNEL  
Give the title, responsibility, name, business and home addresses, and telephone numbers of all responsible project officers.
  - 1.7** CLASSIFICATION LEVELS  
List all classified phases of the program and the degree of classification.
- 2.** GENERAL INFORMATION
  - 2.1** TEST DESCRIPTION
  - 2.1.1** PURPOSE OF THE TEST  
List the primary and secondary objectives of the test.
  - 2.1.2** LAUNCH WINDOW  
Give the preferred launch time and the allowable period. Also state the controlling factors for determination of the launch window and who may authorize deviation.

**2.1.3**

LAUNCH PARAMETERS

Give the desired launch azimuth and elevation angle, along with the amount they may be adjusted for purposes of range safety or other reasons.

**2.1.4**

PAYLOAD TRAJECTORY CONSTRAINTS

Give the trajectory parameters at staging points, (first burnout, second ignition, etc.). These parameters should include altitude, velocity, slant range, ground range, flight path angle, and azimuth, along with maximum deviation of these parameters allowable for mission success. Plan and profile views of the trajectory are also required. Preliminary data are acceptable until "T"-30 days at which time the final data are required. In certain instances, sufficient data under this item could preclude the Vehicle Description Document.

**2.1.5**

ORBITAL PARAMETERS

The orbital parameters should include apogee, perigee, orbital inclination, period, and a plot of the Earth track for three orbits.

**2.1.6**

RECOVERY

State and describe what is to be recovered, reasons for recovery, hazards involved, and any recovery aids and their characteristics. Include aids such as chaff (frequency, quantity), SARAH beacon (frequency, power output, period of operation), dye marker (color, persistence, time of deployment), flashing light (color, frequency, duration, candle power, directional characteristics), smoke (color, duration, time of deployment), radar reflective parachute (when deployed, size), or any other aids used. Also give the desired period of recovery operations and the disposition of the recovered item.

**2.2**

PAYLOAD LAUNCH RESTRAINTS

**2.2.1**

WEATHER

State local and downrange weather restrictions other than those pertaining to vehicle design limitations and range operational constraints. State the maximum cloud cover allowable and the necessary visibility. Give any other limiting conditions such as precipitation, humidity, temperature, etc.

**2.2.2**

TECHNICAL DIFFICULTIES

State conditions which will necessitate cancellation or a mandatory hold, exclusive of range and vehicle operation requirements, due to lack of support from the following areas: communications, payload telemetry, ground telemetry, mobile telemetry, ground radar, mobile radar or optical coverage.

**2.2.3**

REVIEW OF PAYLOAD LAUNCH RESTRAINTS

State who is responsible for review of payload launch restraints to determine possible relaxation of test conditions and who shall have final authority on relaxing any of the payload test requirements.

**3.**

PAYLOAD TECHNICAL DATA

**3.1**

PAYLOAD DESCRIPTION

**3.1.1**

PAYLOAD DIMENSIONS

Payload drawings should be supplied showing all dimensions with particular emphasis on heat shield, umbilical and upper-stage interfaces.

**3.1.2**

PAYLOAD WEIGHT BREAKDOWN

Payload weight should be tabulated by major components, including structural instrumentation and total weight.

**3.1.3**

MOMENTS OF INERTIA

Payload moments of inertia should be tabulated by major components along with the total moments of inertia.

**3.2**

HAZARDOUS MATERIALS

**3.2.1**

PYROTECHNIC DETAILS

Six readily distinguishable copies of schematics and wiring diagrams of all pyrotechnic circuits and all other circuits physically or electrically related to pyrotechnics are required. For each squib, show on the drawings the minimum sure-fire current, maximum no-fire current, recommended firing current, nominal resistance and, if available, the r-f characteristics.

Give a description of the power source, including output, battery life, and details on battery charging. Scale drawings must be supplied for any payload having r-f transmitters or beacons showing the location of all pyrotechnic devices in relation to all transmitting antennas. The frequency, range, type of emission, type of radiating antenna and radiated power (both peak and average) shall be shown for each transmitter or beacon. Schematics, drawings, and operational description of pyrotechnic check-out and monitoring equipment, and any other auxiliary equipment must also be supplied. The range must be notified of any changes as it is the range user's responsibility to certify that all drawings are up to date. All pyrotechnic details must be approved by the range.

### 3.2.2

#### RADIOACTIVE MATERIALS

If radioactive materials are used in the payload or any of the checkout procedures, the information in sections 3.2.2.1 and 3.2.2.2 must be supplied.

### 3.2.2.1

#### RESPONSIBILITY FOR RADIOACTIVE MATERIALS

(a) For all radioactive materials planned for use at this station which will involve exposure or possible exposure of personnel, application will be made by Wallops Station to the Atomic Energy Commission for a license granting this station the authority to:

1. Handle, store, ship, and control sources in use at this station.
2. Establish operational procedures and provide monitoring, dosimetry, and the required records.
3. Establish necessary emergency procedures in the event of malfunctions, explosions, or destructive action.
4. Dispose of waste materials.

(b) Permission may be granted by Wallops Flight Station for a licensed range user to possess and control small calibration or other small sources at this station providing:

1. An operational procedure is submitted for storage, handling, shipment, etc.

- 3.3.4      COMMAND SYSTEM**  
Give all electrical details and operational characteristics of any payload command system.
- 3.3.5      OTHER ELECTRICAL SYSTEMS**  
Give all electrical details and operational characteristics of any other payload systems.
- 3.4          FLIGHT SEQUENCE OF PAYLOAD**  
Give a complete activation and flight sequence of events.
- 3.5          SEPARATION SYSTEM**  
Schematics and assembly drawings should be used to show the detail and operation of the separation system.
- 3.6          HEAT SHIELD DETAILS**  
Heat shield details should be listed, including drawings with overall dimensions, forward tip station, bumper forward face station, access hatch requirements, and umbilical door location and size. If heat shield is supplied by the payload agency, design parameters, details on environment testing, and details on heat shield separation should be supplied.
- 3.7          SPIN RATE**  
The required spin rate should be noted, as well as acceptable variations and maximum limitations of spin rate.
- 3.8          PAYLOAD ENVIRONMENTAL DATA**  
State any environmental restraints.
- 3.9          RANGE USER'S GROUND SUPPORT EQUIPMENT**  
State in detail the ground support equipment which will be supplied by the range user. Also, describe the electromagnetic radiation characteristics of special equipment, including the purpose or function of the equipment, type of emission, average and peak power output, modulation characteristics, antenna description, and expected location of equipment with respect to the test vehicle launch site.

**4.1.2.9      ADDITIONAL REQUIREMENTS**

Describe any additional downrange requirements.

**4.1.3      LOOK ANGLES**

State all look angle requirements.

**4.2      DATA DISPOSITION**

Tabulate the data required from all sources, the number of copies needed, and to whom the data should be sent. Use the following tabular form:

<u>Item No.</u>	<u>Short Description</u>	<u>No. of Copies</u>	<u>When Required</u>	<u>Recipient</u>
X	XXXXXX	XX	XXX	XXXX

**4.3      PAYOUT LOAD PREPARATION SUPPORT**

**4.3.1      RANGE FACILITIES**

State requirements for range facilities, including work shop, machine shop, etc.

**4.3.2      DYNAMIC BALANCE REQUIREMENTS**

For dynamic balancing, the range user is required to furnish the following: center of gravity, the plane locations for the addition of weights, the radius arm from the geometric center for weight placement, dynamic balancing speed, any special environmental conditions such as temperature, humidity, maximum acceleration and deceleration, and any special balance procedures.

**4.3.3      INERTIA DETERMINATION**

State the requirements for experimentally determining moments of inertia of the payload. Also describe the methods to be used and the attach points for swinging.

**4.3.4      GROUND SUPPORT EQUIPMENT REQUIRED**

State the ground support equipment required from the range in detail. Consideration should be given to relative location, electrical and mechanical assembly areas and furnishings, heavy and light equipment, and machinery and transportation facilities.